STRENGTHENING MATHEMATICS SKILLS AT THE POSTSECONDARY LEVEL: PROMISING PRACTICES IN COMMUNITY COLLEGES, BUSINESSES, AND THE MILITARY

U.S. Department of Education
Office of Vocational and Adult Education
Division of Adult Education and Literacy
2005

STRENGTHENING MATHEMATICS SKILLS AT THE POSTSECONDARY LEVEL: PROMISING PRACTICES IN COMMUNITY COLLEGES, BUSINESSES, AND THE MILITARY

Prepared for:
U.S. Department of Education
Office of Vocational and Adult Education
Division of Adult Education and Literacy

Prepared by:
The CNA Corporation

Contributors:
Peggy Golfin, The CNA Corporation, Alexandria, VA
Darrell Hull, Center for Occupational Research and Development, Waco, TX
Monya Ruffin, American Institutes for Research
Education & Human Development, Washington, D.C.

This publication was produced under U.S. Department of Education Contract No. ED-01-CO-0037 with The CNA Corporation. Carolyn Lee served as the contracting officer's technical representative. The views expressed herein do not necessarily represent the positions or policies of the Department of Education. This publication includes information about and references to products, commodities, services or enterprises from other organizations, both public and private. Inclusion of these does not constitute an endorsement of them by the U.S. Department of Education.

U.S. Department of Education
Margaret Spellings
Secretary

Office of Vocational and Adult Education
Susan Sciafani
Assistant Secretary

June 2005

To order copies of this report,

call in your request toll-free: 1-877-433-7827 (1-877-4-ED-PUBS). If 877 service is not yet available in your area, call 1-800-872-5327 (1-800-USA-LEARN). Those who use a telecommunications device for the deaf (TDD) or a teletypewriter (TTY) should call 1-877-576-7734; or

order online at: www.edpubs.org; or

e-mail your request to: edpubs@inet.ed.gov; or

write to: ED Pubs, Education Publications Center, U.S. Department of Education, P.O. Box 1398, Jessup, MD 20794-1398; or

fax your request to: (301) 470-1244;

This report is also available on the Department's Web site at

www.ed.gov/offices/OVAE/……….

On request, this publication is available in alternate formats, such as Braille, large print, audiotape, or computer diskette. For more information, please contact the Department’s Alternate Format Center at (202) 260-9895 or (202) 205-8113.

Contents

LIST OF FIGURES

LIST OF TABLES

Table | Page

ABBREVIATIONS

AACC	American Association of Community Colleges
AASCU	American Association of State Colleges and Universities
AAU	Association of American Universities
ABE	Adult Basic Education
ACCUPLACER	College Placement Exam
ACT	A not-for-profit organization in the field of education and workplace development. The acronym also refers to the college entrance exam developed by ACT
AECF	Advanced Electronics/Computer Field
AFQT	Armed Forces Qualifications Test
ALEKS	Assessment and LEarning in Knowledge Spaces
AMATYC	American Mathematical Association of Two-Year Colleges
ANOVA	Analysis of Variance
AP	Advanced Placement
ARC	American River College
ASSET	Assessment of Skills for Successful Entry and Transfer
ASVAB	Armed Services Vocational Aptitude Battery
BLS	Bureau of Labor Statistics
BSEP	Basic Skills Education Program
CAI	Computer-Assisted Instruction
CAS	Computer Algebra Systems
CCD	Community College of Denver
CCSSE	Community College Survey of Student Engagement
CERP	Career Exploration Research Project
CGCC	Chandler-Gilbert Community College
CNA	Center for Naval Analyses
CNAC	CNA Corporation
CNO	Chief of Naval Operations
COMPASS	Computerized Adaptive Placement Assessment & Support System
COTS	Commercial off the Shelf
CPT	Computerized Placement Test
CRAFTY	Curriculum Renewal Across the First Two Years
CRLA	College Reading and Learning Association
DOD	Department of Defense
DTIC	Defense Technical Institute Center

DTMS	Descriptive Tests of Mathematical Ability
ERIC	Educational Resources Information Center
ESTP	Enhanced Skills Training Program
FGSS	First Generation Student Success
FY	Fiscal Year
GED	General Equivalency Diploma
GPA	Grade Point Average
GRCC	Green River Community College
GT	General Technical
HACC	Harrisburg Area Community College
HSDG	High School Degree Graduate
IP	In Progress
IPEDS	Integrated Postsecondary Education Data System
ISP	Informed Self-Placement
KCC	Kapiolani Community College
KSAs	Knowledge, Skills and Abilities
LEARN	Learning Early Alert Retention Network
MAA	Mathematical Association of America
MAPS	Mathematics Advising Placement Sessions
MARC	Math Activities Resource Center
MASP	Military Academic Skills Program
MARS	Math Anxiety Reduction/Retention Student Success
MDTP	Math Diagnostic Testing Project
MLC	Math Learning Center
MPS	Math Performance Success
NADE	National Association for Developmental Education
NCC	Northampton Community College
NCCBP	National Community College Benchmark Project
NCLC	Navy College Learning Centers
NCPACE	Navy College Program for Afloat College Education
NETPDTC	Naval Education Training Professional Development Technology Center
NHSDG	Non-High School Diploma Graduate
NSSE	National Survey of Student Engagement
NVC	Northwest Vista College
OCC	Onondaga Community College
OVAE	Office of Vocational and Adult Education
RCT	Randomized Controlled Trial
ROI	Return on Investment
ROTC	Reserve Office Training Corps
SAT	College Entrance Exam
SI	Supplemental Instruction
SMASH	Student Attitude/Math Anxiety Study Habits

SOC	Servicemembers Opportunity Colleges
SPIN	Special Professional Interest Network
SS&RSC	Student Success and Retention Services Center
SUNY	State University of New York
TA	Tuition Assistance
TABE	Test of Adult Basic Education
VolEd	Voluntary Education

PREFACE

The U.S. Department of Education Office of Vocational and Adult Education (OVAE) created this project to benefit educators in Adult Basic Education (ABE) and those in the field of developmental mathematics at the postsecondary level. In particular, the two main goals of this work are (a) to identify the level of math skills and knowledge necessary to successfully pursue college-level math and (b) to describe promising practices in community colleges, businesses, and the military that enable adult learners to strengthen their math skills and abilities and to transition into higher-level math courses or work assignments requiring higher-level mathematics.

The first phase of this work was published previously in a document by Golfin et al. (2005), "Strengthening Mathematics Skills at the Postsecondary Level: Literature Review and Analysis." We refer interested readers to that document for a detailed description of our review of the literature pertaining to the specific knowledge and skills necessary to pursue college-level mathematics, common assessment tests and their cutoff scores for placement into college-level mathematics, and salient themes in the literature concerning promising pedagogical practices.

This document provides a detailed description of results from the second phase of the project, specifically findings from our search of exemplary community college and business developmental math programs, as well as a summary of the basic mathematics skills instruction provided by the military for servicemembers. Our focus is primarily on mathematics at the level of introductory and intermediate algebra.

Herein, we provide information pertaining to common practices in a sample of community colleges taken from the Internet, as well as in the ten community colleges with promising practices selected for this study. Examples of the types of information include placement practices, pedagogical approaches, credit type and course convening times, calculator practices, software use, textbooks, availability of computer labs and tutors, exit strategies, and grading policies. Much of what we have documented can be described as "the state of the practice," and, as such, the information may be especially useful for educators who are starting up a new developmental mathematics course or program and are looking for guidance as to the appropriate text, subject matter, software, calculator, and so on.

More important, we provide a summary of what we deduce to be the most effective strategies in developmental mathematics at the postsecondary level. Our recommendations are not derived from scientifically based studies; indeed,

these types of studies, because they are so difficult, are very rare. Instead, we have synthesized what we have found from the literature review, from a number of recent surveys (including the Community College Survey of Student Engagement (CCSSE)), and from our evaluation of promising practices from the ten colleges included in this study, noting those strategies that appear to have the most supporting, albeit circumstantial, evidence, and that are fairly pervasive in these successful institutions.

Much valuable work remains to be done in this field, especially in terms of gathering better data and conducting more rigorous multivariate analysis that controls for flaws in many of the published studies we identified, especially self-selection bias. Even so, the practices identified and described in this document are excellent candidates for future research in this field, and many, if implemented either in part or in whole, should prove valuable to most developmental mathematics instructors and, ultimately, their students.

ACKNOWLEDGMENTS

The authors wish to thank all of the people in the institutions that we contacted who responded to our inquiries, who provided us with data and shared information concerning their developmental mathematics programs, and who made recommendations of exemplary programs for us to pursue.

Institutions

American River College (CA)
Asheville-Buncombe Technical Community College (NC)
Chancellor's Office, California Community Colleges
Chancellor, Massachusetts Board of Higher Education (MA)
Chancellor, State System of Higher Education (PA)
Chandler-Gilbert Community College (AZ)
Cleveland Community College (NC)
Community College of Denver (CO)
Community College of Philadelphia (PA)
CUNY University Dean for Institutional Research (NY)
De Anza College (CA)
Delaware County Community College (PA)
Dona Ana Branch Community College (NM)
Fullerton College (CA)
Gavilan College (CA)
Green River Community College (WA)
Harrisburg Area Community College (PA)
Hawaii Board of Regents (HI)
Highline Community College (WA)
Hinds Community College (MS)
Illinois Board of Higher Education
Kapiolani Community College (HI)
Louisiana Commissioner of Higher Education (LA)
Maryland Secretary of Higher Education (MD)
Miami Dade Community College (FL)
Middlesex Community College (MA)
Mississippi State Board for Community and Junior Colleges (MS)
Montgomery College, Tacoma Park (MD)
Moraine Valley Community College (IL)
Mount San Antonio College (CA)
North Carolina Community College System (NC)
Northampton Community College (PA)
Northern Essex Community College (MA)
Northwest Vista College (TX)

Ohio Board of Regents (OH)
Oklahoma State Regents for Higher Education
Onondaga County Community College (NY)
PA Commission for Community Colleges (PA)
Pierce College (WA)
Porterville College (CA)
Prince George's Community College (MD)
Richland Community College (IL)
Santa Fe Community College (NM)
SUNY System Administration (NY)
University of New Mexico - Valencia Campus (NM)
Washington State Board for Community and Technical Colleges
Waycross College (GA)
Wyoming Community College Commission (WY)
Zane College (OH)

Individuals

Jeff Cropsey, Director, VolEd Department, Navy Education and Training, Professional Development and Technology Center
Ann Hunter, Head, Education Branch, Navy Education and Training Command
CDR Diane Mielcarz, Navy Education and Training
Vernon Taylor, Marine Corps Head, Lifelong Learning
Adele Winter, NovaNet Account Executive & Army Consultant (Cadet Command), Pearson Digital Learning

Technical Working Group

We appreciate the valuable feedback and advice provided throughout our project by the expert members of our Technical Working Group (TWG):

Susan Chipman, Office of Naval Research (VA)
Frank Demana, Professor Emeritus of Mathematics at the Ohio State University (OH)
Francis Fennel, McDaniel College (MD)
Robert Franks, Texas State Higher Education Coordinating Board (TX)
Lynda Ginsburg, Rutgers University (NJ)
Robert Kimball, Wake Technical College (NC)
Marilyn Mays, North Lake Community College (TX)

Other Contributors

We would like to thank the following people at The CNA Corporation who also contributed to this research: Lou Jacobsen, Laura Wyshynski, Tara Harrison, and Miguel Martinez.

Reviewers

For their thoughtful review of this document, we would also like to thank Elizabeth C. Powers, Director, Teacher Quality Grants Program, Texas Higher Education Coordinating Board and Jeffrey Morford, Chair, Foundation/Developmental Mathematics Committee of the American Mathematical Association of Two-Year Colleges.

EXECUTIVE SUMMARY

The nature of America's workforce has changed dramatically in the recent past, with rapid changes in technology driving businesses' increased requirements for more technical skills from their workers. Strong math competence is fundamental to these technical skills, yet as many as one in four businesses must turn away applicants because of deficient math skills (National Association of Manufacturers Center for Work Success 2001).

Although college enrollments have increased significantly in response to this increasing demand for workers with advanced education, many freshman entering community college—from recent high school graduates to adults who have been out of school for a number of years—find their goal of earning a college degree and bettering their lives frustrated by the fact that they are ill prepared to succeed at college-level mathematics (NCES 2003 (b)). Many drop out of college, never realizing their goals, because they are required to take multiple developmental math courses that are often just repetition of the material they couldn't master in high school (Grubb 1999, NCES 2003b Table 5, NCES 2003 Table 313).

The U.S. Department of Education Office of Vocational and Adult Education (OVAE) created this project with two main goals: (i) identify the level of math skills and knowledge necessary to successfully pursue college-level math and (ii) describe promising practices in community colleges, businesses, and the military that enable adult learners to strengthen their math skills and abilities and to transition into higher-level math courses or work assignments requiring higher-level mathematics.

Our work proceeded in two phases. The first phase involved a review of the literature to establish a baseline understanding of postsecondary developmental mathematics programs. Findings from that work are summarized in the document, "Strengthening Mathematics Skills at the Postsecondary Level: Literature Review and Analysis" (Golfin et al. 2005).

In the second phase of the project, we searched community colleges, businesses, and the military to find promising practices in the field of developmental mathematics. It is this second phase that we summarize in this document.

For a number of reasons, we confine a summary of our findings here to community colleges. As we describe in the report, an exhaustive search did not yield examples of businesses that offer the level or extent of developmental mathematics instruction we are concerned with in this study. Further, neither the businesses we contacted nor the military have conducted analyses of the effectiveness of their various training strategies in mathematics. However, some branches of the military and a significant number of businesses contract with community colleges to provide

basic skills instruction. These are the practices we summarize here.

Summary of Findings

What Constitutes Adequate Math Preparation?

Recommendations from a number of leading studies, including the American Mathematical Association of Two-Year Colleges (AMATYC) (1995, 2002a, 2002b), indicate that in order to pursue college-level mathematics, students need to have a good foundation in their knowledge of arithmetic, geometry, trigonometry, and algebra I and II. Emerging work also indicates the need for basic statistics and the ability to analyze data.

The skills necessary to pursue college-level math and to succeed in the highest-paid and highest-skilled jobs are equally important, if not more so. These skills include the need to think critically, to solve problems, and to communicate mathematically. Businesses and postsecondary institutions that were surveyed as part of large curriculum reform efforts indicate that they want people who can identify a problem, determine whether it can be solved, know which operations and procedures are required to solve it, use multiple representations (such as graphs and words) to describe problems and solutions, and understand and apply mathematical modeling. Such skills however, are often more difficult to teach and assess than specific knowledge (American Diploma Project 2004).

Our research indicates that community colleges have fairly uniform curricula in terms of the content knowledge, and this content conforms to the recommendations we cited, but there is less uniformity in the teaching of the recommended skills. Community colleges whose developmental math curricula include both the knowledge and skills recommended in these studies are in the best position to serve their students as well as the business community.

We have found a growing controversy concerning the best assessment tools to determine whether incoming students possess both the knowledge and skills necessary to pursue college-level mathematics. In particular, there is disagreement as to whether the most commonly used tests accurately assess the skills we referred to above. Regardless, most two-year colleges require incoming students to take and pass some type of assessment test before they are allowed to enroll in college-level math courses. Given their prevalence, this may be the most relevant benchmark for whether a student can successfully transition to college-level mathematics.

Deleted: ¶

Best Instructional Practices

Our extensive search of the developmental education literature yielded only a limited number of studies pertaining to adult developmental mathematics

instruction, the majority of which has been conducted in two-year colleges. None of these, however, were derived from scientifically based experiments. The greatest difficulty in drawing conclusions from most of these studies is their failure to control for what is known as self-selection bias, which results when students have choice over different approaches to teaching. Bias is inherent, say, if more highly motivated students or students with fewer challenges (such as family, work and so on) self-select classes with new and innovative approaches. If so, the average success rate of students in those classes might be greater than that of students in traditional classes because of the characteristics of the students selecting the course, and not because of the new approach itself.

Even so, salient themes concerning pedagogy emerged, suggesting promising but unproven instructional practices. Our work in the second phase of this project echoes these same themes and suggests some additional ones. Before we summarize these practices, it is important to provide some additional background information.

Other Factors Related to Success

Our search of highly successful programs, combined with the findings from the CCSSE, makes it clear that characteristics of the student body served have a significant impact on overall success. Students who face additional college requirements that developmental courses impose have varying degrees of success in those courses depending on factors and challenges that go well beyond classroom strategies. Knowing what these challenges are, especially for the particular population served by the institution, is vital in addressing the full spectrum of their developmental needs.

Most striking from the CCSSE is the fact that developmental students report that they are more likely to drop out of college due to financial and family pressures than because they are academically underprepared. Developmental students as a whole tend to require more services than nondevelopmental students, and older developmental students require more than younger ones. Especially important to developmental students are academic advising, computer labs, and skill labs. We found that, at least in terms of math learning labs and tutoring, most community colleges are addressing these needs to some degree.

Recommendations

Providing an effective developmental mathematics program that supports students, encourages their academic achievement, and ensures their success requires a strong commitment on the part of administrators, faculty, support personnel, and the students themselves. While success doesn't come cheaply or easily, dropping out of college has financial consequences that accrue to the institution, the individual, and the community at large.

First, our research indicates that the traditional lecture format remains the most prevalent instructional approach. Although many colleges offer online options, computer-assisted courses, or some other hybrid mixture of delivery methods, we have not identified sound, consistent research that indicates that these methods are demonstrably superior to the traditional classroom approach. In fact, we deduce that the nature of computer-based instruction is counter to many of the strategies that appear to be most beneficial to students taking developmental math courses. Both the review of the literature and the consensus of practices in our exemplary colleges agree that students require a variety of approaches to learning. Instructors need to use a number of instructional tools to explain and reinforce the material, such as real-world examples, multidisciplinary examples, project work, traditional lecture, interactive computer software, and—especially important—collaborative group work.[1] Therefore we suggest the use of technology in the traditional classroom since it provides one more approach to learning that may resonate particularly well with certain types of learners, especially when used in conjunction with a number of other approaches.

Second, there is substantial evidence that peer study groups are a cost effective method for addressing many of the recommendations in this report. This approach is especially effective if it includes instruction in study skills, which we find to be an essential component of developmental mathematics curricula.

Third, developmental mathematics students further benefit by having:

- Availability of computer labs and tutors in off-hours, such as evenings and weekends, and orientation to those services;

- Regular assessments that make minimal use of traditional paper and pencil tests, and that focus on critical thinking skills;

- Required mastery of each component of a course at a minimum threshold before moving on to new material;

- Increased time on task—in the form of longer class convening, labs, study groups, and so on;

- Ample opportunity to practice their skills, both in and out of the classroom, and to use multiple approaches to problem-solving;

- Common syllabi and common exams across all sections of the same course;

[1] See the glossary for a definition of terms regarding pedagogy, statistical concepts, and so on.

- Mandatory placement to ensure a proper match between the students' skills and the initial level of the course material;

- A supportive classroom atmosphere that encourages questions and discourages negative feedback from instructors;

- Career exploration activities.

- All instructors, both adjunct and full-time, specifically trained in classroom techniques that have the greatest evidence of enhancing success.

Finally, although our extensive research has provided an impressive amount of evidence that supports our findings that these strategies are indeed promising, we lack the necessary scientifically based evidence to conclude that they are successful strategies for developmental math students at the postsecondary level. Nor do we know whether particular strategies are effective for all learners, or whether some benefit one type of learner disproportionately.

More research is needed in this area, and would prove to be extremely valuable, but such research is difficult to conduct, especially in randomized controlled trial (RCT) experiments. Even so, scientifically sound analysis can be conducted in the absence of such experiments—research that measures as many extraneous factors as possible and controls for their effects in multivariate analyses. Our research has found that even this level of scientifically based validation of promising practices is fairly difficult; colleges often lack the data necessary to control for student characteristics, such as race, gender, age, and education credential, and are constrained by the inability to follow students if they transfer to other institutions. Nevertheless, much could be done with existing data to advance our understanding of which strategies are most effective, and perhaps even why.

INTRODUCTION

Demand For Skilled Workers

The nature of America's workforce has changed dramatically in the past several decades, due in large part to the infusion of rapidly changing technology. This trend has resulted in an increased need for workers with greater skills and higher education. For instance, the Bureau of Labor Statistics (BLS) (BLS 2001) predicts that jobs requiring at least a bachelor's degree will grow 21.6 percent[2] between 2000 and 2010, and those requiring an associate degree or vocational certificate will increase 24.1 percent. In contrast, jobs requiring only work-related experience will increase just 12.4 percent during the same time period.

Supply of Skilled Workers

In spite of these trends, employers are finding that their workforce is simply not prepared to meet even the most basic skill requirements, including reading, writing, and mathematics. The National Association of Manufacturers found in a 2001 survey sent to its members that 80 percent of manufacturers experience a moderate to serious shortage of qualified job candidates, and that 26 percent of employers listed inadequate math skills among the most serious skill deficiencies (National Association of Manufacturers Center for Work Success 2001). Further, 20 percent said that they rejected applicants for hourly production positions due to inadequate math skills.

This upturn in deficient skills is in large part a function of the rapidly increasing skill requirements and the changes in these requirements over the past few years. In other words, it is not just a matter of employers requiring more workers to know math; the type of math required is also changing.

Trends in College Enrollment and Developmental Education

Partially in response to the needs of employers and the higher wages that high-tech jobs offer, the rate of college enrollment of graduating high school seniors has increased significantly since the last half of the twentieth century, from 45 percent in 1960 to 62 percent in 2001 (NCES 2003, Table 184). Even so, studies find that a large proportion of those who enroll in college are not prepared to pursue college-level courses; 35 percent of entering freshmen at public two-year colleges in 2000 were enrolled in remedial mathematics courses, an increase of almost 10 percent from just

[2] Throughout this document, we express changes in various phenomena in percent terms, rather than a percentage point change. As an example, an increase in a given metric from 10 percent to 17 percent is a 70 percent increase (0.17/0.10 minus 1), and a 7 percentage point increase (0.17 minus 0.10).

five years earlier (NCES 2003b Table 4). That same study revealed that students who require developmental education courses are also taking longer to complete those courses; 63 percent of these students in public two-year colleges take an average of one or more years to complete all developmental courses, an increase of over 14 percent from 1995 (NCES 2003b Table 5).

But are these remedial courses successful in helping students to achieve their education and career goals? The general consensus is that successfully remediated students do perform well in standard college-level courses (McCabe 2000), but that begs the question of what happens to students who do not successfully complete their developmental studies, either because they cannot master the subject—which in many cases is a repeat of material that they were unable to master in high school—or because the additional time and costs required to complete developmental courses creates insurmountable financial, work, and family burdens on students.

The reasons for dropping out of college can be complicated and often intertwined. The fact is that the dropout rate is fairly high for all students in public two-year institutions; only about one in three graduate within five years of first enrolling (NCES 2003 Table 313). But developmental education students face even greater challenges. As we discuss later, these students in their first year of a community college program state that they are far more likely to drop out of college than their nondevelopmental classmates for many reasons, including financial strains, caring for dependents, working full-time, and being academically unprepared.[3]

The solution is not to reduce the requirements for developmental education. Studies have found that relatively few students—one estimate is less than one in ten—who require remediation but do not receive it will be successful in college (Boylan and Saxon 2002).

One option is to establish higher standards for high school graduation. While some states have done so, this is certainly not widespread. According to the U.S. Department of Education, only four states[4] required students to have four Carnegie Units (each unit is roughly equivalent to one academic year of study) in mathematics for high school graduation in 2001, seventeen of the remaining states only required two units, and the rest required three (NCES 2003 Table 152).

Clearly, some students can take more math than what is mandated by state law for high school graduation, and some states recommend more math for college-bound students. According to Barth (2002), the percentage of students completing

[3] Based on the CCSSE, which we describe in detail in a later section.

[4] Alabama, Georgia, North Carolina, and South Carolina are the four states that required four units of math.

algebra II in high school, the minimum content typically required to enroll in college-level mathematics, has grown from 40 percent to 62 percent between 1982 and 1998.

Improving the math skills of high school graduates will address one aspect of the problem of increasing numbers of college freshman required to take developmental mathematics. But that does not address the needs of high school dropouts who enroll in Adult Basic Education (ABE) programs or of adults who attend community college years after high school graduation.

The Purpose of This Study

The Office of Adult and Vocational Education of the U.S. Department of Education created this project to benefit community colleges, businesses, the military, and ABE programs in addressing the need to remediate basic math skills of their students and workforce. ABE programs are the prime targeted beneficiaries of this research, so at times we emphasize program elements that address their particular circumstances and needs. The findings of this research, however, are generally applicable regardless of the institution or the age or education credential of the learner.

In particular, this study provides a compendium of information that leading research indicates is the appropriate curriculum and pedagogy for teaching developmental mathematics, it documents the state of the practice, and it identifies successful strategies that are used by programs with promising results. We turn to community colleges, businesses, and the military for guidance as to successful strategies because of the services they provide to the large population of matriculated students and to their workforces.

In this document, we briefly summarize findings from the first phase of this project that are described in greater detail in the document, "Strengthening Mathematics Skills at the Postsecondary Level: Literature Review and Analysis" (Golfin et al. 2005). In particular, we review the necessary knowledge and skills recommended by leading studies for pursuing college-level mathematics, and provide a brief discussion of some of the principle successful strategies suggested by our review of the literature.

We then turn to a detailed description of the research conducted in the second phase of this project. Specifically, we describe results from a number of surveys of common community college practices, including a sampling of colleges from the Internet that we conducted; results from the CCSSE, which provides us with a unique insight into various characteristics, goals, and challenges faced by developmental students, especially older ones; the methodology we used in selecting exemplary community colleges with promising practices and our detailed

description of the programs in each; a summary of four businesses programs that provide basic skills instruction to workers; and a description of basic skills instruction to members of the U.S. military.

For ease of reference, we provide a cross reference to the information provided in this document pertaining to various attributes of developmental mathematics courses, faculty, and student body, along with the first page of the relevant subsection(s), in table 1 below.[5] Each topic is differentiated by whether the discussion is based on published research, our random sample of colleges taken from the Internet or national surveys (referred to as common practices), or the colleges we chose for having promising practices.

Table 1: Selected topics and corresponding subsection page numbers

	Section Page Number		
Topic	Research	Common practices	Promising practices
Academic advising		35	63, 67, 72, 87, 90, 98, 158
Attendance policies		26	139
Calculator policies	12	20	78, 171
Career counseling	12	34	63, 98, 109
Collaborative learning	12	19	67, 72, 78, 81, 87, 90, 94, 98, 109
Credit type		15, 24	55, 81, 167
Faculty characteristics or training		15	81, 87, 90, 94, 98, 109, 176
Frequent assessment			81, 109
Grading policies			78, 90, 94, 98, 167
Knowledge and skills	7	25	
Labs – class or computer labs	12	19, 35	55, 78, 81, 87, 90, 94, 98, 163
Learning Communities		33	67, 81, 87
Levels of courses	15	24	158
Math anxiety			63, 72, 87

[5] We only include subsections in which there is a significant discussion of the topic.

Topic	Research	Section Page Number Common practices	Promising practices
Measures of success		43	39, 58, 63, 67, 72, 78, 81, 87, 90, 94, 98, 137, 138, 177
Online or self-paced courses	15	19	67, 78, 94, 98, 109
Pedagogy	12	19	39, 58, 63, 67, 72, 78, 81, 87, 90, 94, 98, 135, 136, 138, 139, 167
Placement policies	10	15	55, 58, 67, 72, 78, 81, 87, 90, 94, 109, 135, 137, 138, 139158
Real-world examples	12		67, 72, 78, 81, 87, 94
Software	12, 15	15, 21, 22	67, 78, 94, 171
Student characteristics			
Aspirations		29	51
Challenges		31	46, 53, 67, 104
Credentials		29	
Demographics			46, 58, 63, 67, 72, 78, 81, 87, 90, 94, 98
Services requested		35	72
Survey feedback		153	58, 63, 72, 81
Study groups		19	58, 72, 78, 81, 87, 94, 98, 109
Study skills		19	58, 63, 67, 72, 81, 87, 98
Textbooks		21, 149	81, 171
Time on task – including class convening		19	55, 58, 63, 67, 72, 78, 81, 109, 135, 139, 167
Transition out of developmental math			55, 158

Topic	Research	Section Page Number Common practices	Promising practices
Tutoring		26	55, 72, 78, 87, 94, 98, 163
Uniform curriculum			58, 67, 72, 90, 109

SUMMARY OF LITERATURE REVIEW FINDINGS

We refer interested readers to the literature review for a full discussion of the research we reviewed and our comprehensive findings. Below we summarize the most important insights from that research, especially concerning what students need to know to pursue college-level mathematics, common placement practices of community colleges, and salient themes concerning promising pedagogical practices. Because community colleges provide the majority of developmental mathematics instruction, including those services to businesses and the military, we confine our summary to community college practices here. We will discuss specific military and business research findings later.

What Should Students Know To Pursue College-Level Mathematics?

The first step in our identification of successful developmental mathematics curricula is to identify precisely what students should know. This involves two broad categories: (a) the knowledge, or content, and (b) the skills and abilities necessary to enroll in college-level mathematics in community colleges. By knowledge we refer to the specific math facts or subjects, such as ratios, decimals, and solving linear equations. By skills we refer to observable competencies to perform a function. For instance, critical thinking, generating ideas, and determining which tool is necessary to do a job are considered skills. Abilities are attributes that affect the ability to perform a task, such as manual dexterity and inductive and deductive reasoning.

There is general consensus in the requisite knowledge recommended by leading community college mathematics research, some of which we discuss below. Likewise, there is agreement on the skills and abilities, and they resonate with the needs expressed by businesses. In particular, there seems to be widespread consensus as to the need to think critically, to solve problems, and to communicate mathematically.

Several studies provide more precise definitions of the knowledge and skills at the postsecondary level. We reviewed four of the most comprehensive, and probably most important, of these; together they form a thorough set of recommendations.

Those studies include:

- *Crossroads in Mathematics: Standards for Introductory College Mathematics Before Calculus* (hereafter referred to simply as *Crossroads),* published in 1995 by the American Mathematical Association of Two-Year Colleges (AMATYC). This is the most frequently cited of any study of developmental mathematics at the postsecondary level.

- *Standards for Success* (Conley and Bodone 2002). This study reports findings from a collaborative group of 400 representatives from numerous universities, in which they formulated key knowledge and skills necessary for university success in entry-level courses compared with just high school preparation. The Pew Charitable Trusts and the Association of American Universities (AAU) sponsored their work.

- *A Vision: Final Report From the National Conference on Technical Mathematics for Tomorrow* (AMATYC 2002b), hereafter referred to as *Vision. Vision* refers to work coordinated by AMATYC under the National Science Foundation grant, "Technical Mathematics for Tomorrow: Recommendations and Exemplary Programs." At a recent national conference, over eighty educators, technical personnel from business and industry, and technical faculty from two-year colleges identified what they defined as exemplary practices in mathematics programs that serve highly technical curricula, such as biotechnology, computerized manufacturing, electronics, information technology, semiconductors, and telecommunications. Their research built on that conducted by those of the Mathematical Association of America's (MAA) subcommittee on Curriculum Renewal Across the First Two Years (CRAFTY), which also participated in this conference.

- The American Diploma Project (2004), a joint venture of Achieve, Inc., the Education Trust, and the Thomas Fordham Foundation, and supported in part by a grant from the William and Flora Hewlett Foundation. The National Alliance of Business was also an original partner of the project. We refer to this publication by project name rather than by title. The goal of this work was to realign high school diploma requirements with the expectations of employers and postsecondary institutions, to, in their terms, reestablish the value of a high school diploma. The starting point was to describe the English and math skills that high school graduates need to succeed in postsecondary education or in high-performance, high-growth jobs. The work of the American Diploma Project was based on a close collaboration with K-12, postsecondary, and business leaders in such occupations as health care, information technology, telecommunications, high-tech manufacturing, semiconductor technology, law, energy, retail, and financial services.

The four studies are consistent in their recommendations that students should have a basic foundation in geometry, trigonometry, algebra I and II, and some basic statistics before pursuing college-level mathematics. And all four studies emphasize the importance of mathematical skills, particularly critical thinking skills. This research also indicates the necessity of tailoring the preparation to the types of college math and career path that the person intends to pursue.

We summarize the recommendations of these studies into simple tables for ease of use. Recommendations concerning knowledge content are in table 2. Table 3 lists specific skills and abilities that are recommended.

Table 2: Recommended knowledge necessary to pursue college-level mathematics from major studies

Subject	Content
Arithmetic	Add, subtract, multiply, divide fractions, integers, decimals
	Exponents
	Scientific Notation
	Radicals
	Absolute Value
	Terminology of irrational numbers, natural numbers, integers, rational numbers
	Basic operations on sets
	Rates, proportions, ratios, percentages
	Correct order of operations to evaluate arithmetic expressions
	Basic number theory concepts, such as prime number, least common multiple, greatest common divisor
Algebra	Add, subtract, multiply, divide, factor polynomials
	Operations on rational expressions
	Properties and basic theorems of roots, exponents, logarithms
	Solve linear and absolute value equations
	Solve linear and absolute value inequalities
	Solve systems of linear equations and inequalities
	Solve quadratic equations
	Properties of functions
	Slope – intercept form of an equation of a line
	Graph of a line, and quadratic and exponential functions
	Various applications of sequences and series
	Binomial theorem and its connections to combinatorics
Geometry	Properties of parallel, perpendicular lines
	Similarity of figures and use the scale factor to solve problems
	Proofs, axioms, definitions, theorems
	Coordinate geometry: lines, cones, Pythagorean Theorem, vectors
	Basic theorems of congruent and similar triangles
Trigonometry	Definition of ratios – sine, cosine, tangent
	Identities for sum and differences of angles
	Periodic graphs

	Solve problems using exponential models
	Double and half angle formulas
	Basic right triangle trigonometry and applications to solve problems
Statistics	Measures of central tendency and variability
	Different methods of curve fitting
	Probability concepts

Table 3: Recommended skills and abilities necessary to pursue college-level mathematics from major studies

Skills and Abilities
Use inductive and deductive reasoning
Use multiple representations to solve problems
Understand abstract mathematical ideas in word problems, pictorial representations, and applications
Demonstrate strong memorization skills
Know how to estimate or approximate and when it is more appropriate than an exact solution
Understand the appropriate use of technology, and know how to use spreadsheets, graphing calculators, and Computer Algebra Systems
Go from general to abstract and back, and from specifics to abstract and back
Understand that problems have multiple solutions and methods of solution
Recognize and use mathematical models, and use models from other disciplines
Understand the role of definitions, proofs, and counterexamples in math reasoning; construct simple proofs
Use special symbols of mathematics correctly
Distinguish relevant from irrelevant information, identify missing information, and either find what is needed or make appropriate estimates
Test ideas while solving problems, try different approaches, check for errors and reasonableness of solutions
Select and use the best method of representing and describing a set of data
Recognize inappropriate assumptions
Communicate mathematics in writing, graphically, and orally

Assessment and Placement Policies

A basic understanding of placement policies is important for our purposes for a number of reasons. First, according to a recent survey by the American Association

of Community Colleges (AACC), 58 percent of its 400 respondents required students to pass an assessment of basic skills in order to enroll in a college-level math course (Schults 2001). Studies that we reviewed suggest that mandatory student assessment and placement tests have a positive impact on student performance; students who take mandatory placement and assessment tests and subsequently enroll in developmental courses perform better in college-level courses than similar students who do not take developmental courses. Clearly, such policy is an important part of a developmental mathematics program; all of the colleges with promising practices that we reviewed had some type of placement policy in force. As we will see, however, some controversy exists concerning which exams are best at adequately assessing students' knowledge and skills.

The controversy aside, an understanding of the test content and cutoff scores used by community colleges for placement into college-level mathematics is useful because it provides specific information not only about what students should know but also about what level of comprehension is required by colleges that use these instruments.

A number of placement tests are in use, and the cutoff scores vary significantly across institutions. The most commonly used tests include ASSET and COMPASS, both of which are published by ACT, and ACCUPLACER, published by The College Board. Less common are (a) the Test of Adult Basic Education (TABE), produced by CTB McGraw-Hill, (b) the ACT, published by ACT, and (c) the Scholastic Assessment Test (SAT), sponsored by the College Board and published by the Educational Testing Service. In addition, some states have developed their own placement tests.

Because the ACT and SAT are the most common tests used for admission into four-year colleges, both are often cited as acceptable alternative exams if the student took either one before enrolling in the community college. In that case, some colleges exempt students from taking the college-specified placement test if their math subscore is high enough; otherwise they are required to take the placement test. This reflects the fact that placement tests serve two purposes: (a) a screen to determine whether a student is adequately prepared to take college-level math, and, if not, (b) an assessment of the level of developmental math into which to place the student. For instance, neither the SAT nor the ACT help to diagnose whether the student has mastered arithmetic but is weak in elementary algebra; this is precisely what the common placement exams are intended to do.

Placement policy is mandated at a variety of levels: state, community college system level, or individual colleges. There is wide variation in the specifics of these policies, ranging from requirements about who should be tested, with which test, and what cutoff scores, to requirements that all students be tested, leaving the details to the institution. Interested readers may refer to the literature review to learn more

about the specific tests used, the various cutoff scores that were provided to us by a number of states, and guidelines for the comparability of ASSET, ACT, and COMPASS scores provided by ACT, as well as ACCUPLACER cutoff guidelines provided by The College Board.

Research on Instructional Methods

Our review of the literature included fifteen studies of developmental mathematics programs in postsecondary institutions. We chose these studies because they addressed developmental mathematics in particular, they covered a number of different strategies, and they were representative of the body of literature in general. However, we were not able to identify any studies of developmental mathematics that were scientifically based. Even so, we covered these nonscientific studies because we felt that their findings helped to inform our initial understanding of promising programmatic structures and practice. In fact, many of these themes resonate with the programs that we did identify as having promise.

Most of the studies we reviewed concerned the role of technology. Research on education technology has increased tremendously in the past several years, with studies on the effectiveness lagging behind. One topic of debate and uncertainty in the effectiveness of various strategies is in the appropriate use of technology, including questions of how extensively it should be used, as well as the appropriate choice of technology. For instance, one aspect of the debate concerns the type of calculator that students should use—scientific versus graphing.

Some research indicates that, regardless of the type of calculator used, greater success may be realized by changing the emphasis in their use from basic skills to problem solving, using real-world problems or emphasizing the development of critical thinking skills.

The studies we reviewed offered inconsistent conclusions as to whether technology-assisted or technology-based instruction is superior to instructor-led approaches. The strongest argument that we could find, and one that is corroborated by our research into promising practices, is that technology appears to be most useful as a supplement to, rather than a replacement for, regular classroom instruction. All types of technology, including graphing calculators, spreadsheets, and Computer Algebra Systems (CAS), should be used to give students the chance to become familiar with the technology and to understand its benefits and limitations.

Few unambiguous results concerning other pedagogical techniques emerged in our review of the literature. The most definitive finding is that there is general agreement that students require a variety of instructional modes to enhance their mastery of the material. Several researchers contend that allowing students to choose

the instructional method that they feel best suits their particular learning style makes them more likely to complete the course and perhaps take higher-level mathematics.

There is also some evidence that remediation programs require counseling as an integral part of the program. As we will see, this is an important component of the strategies of the colleges in our study.

Finally, we include specific recommendations concerning pedagogy from the *Crossroads* (AMATYC 1995) and *Vision* (AMATYC 2002b) publications. In particular, *Crossroads* specifies that mathematics faculty will:

- Model the use of appropriate technology in the teaching of mathematics so that students can benefit from the opportunities it presents as a medium of instruction;

- Foster interactive learning through student writing, reading, speaking, and collaborative activities so that students can learn to work effectively in groups and communicate about mathematics both orally and in writing;

- Actively involve students in meaningful mathematics problems that build on their experiences, focus on broad mathematical themes, and build connections within branches of mathematics and other disciplines so that students will view mathematics as a connected whole relevant to their lives;

- Model the use of multiple approaches—numerical, graphical, symbolic, and verbal—to help students learn a variety of techniques for solving problems;

- Provide learning activities, including projects and apprenticeships that promote independent thinking and require sustained effort and time so that students will have the confidence to access and use needed mathematics and other technical information independently, to form conjectures from an array of specific examples, and to draw conclusions from general principles.

Further, *Crossroads* specifies that, among other guiding principles, mathematics must be taught as a laboratory discipline.

The *Vision* report recommends that lectures be supplemented by a number of student-centered methods, such as computer simulations and collaborative learning activities, including working in teams. The authors contend that it is not just the pedagogy but the curriculum content that can be effective in teaching mathematics to adults. In particular, the report states that it is important to use activities that engage students in the learning process, such as case studies and projects that require designing, modeling, researching, and presenting findings.

In summary, there is a surprising lack of solid research on the best strategies for teaching developmental mathematics to adult learners, either in isolation or as part of a larger and more comprehensive developmental education strategy. Our next step was to look at common community college practices to understand better what polices and practices were more pervasive and also to find hints as to different components of instruction that were not covered in the literature.

SUMMARY OF OVERALL COMMUNITY COLLEGES DEVELOPMENTAL MATHEMATICS PRACTICES

We turn now to our study of community college developmental mathematics programs. First, we summarize findings of community college practices derived from a survey conducted by the AACC, and a smaller survey that we conducted covering a number of program components that weren't covered in the larger survey. We then turn to a discussion of some characteristics and particular challenges of developmental education students based on the CCSSE. Finally, we present our research into exemplary programs, including a discussion of the methodology that we used to select these programs, general findings from that search effort, and detailed descriptions of the programs we selected.

Survey of Placement Policies, Instructor Credentials, Class Size and Other Factors

In the course of our research into pedagogy and content, we found a number of recommendations that were outside the basics of what to teach and how to teach it, including recommendations of who should teach the courses, what kind of training the instructors should have, student to faculty ratios, and the inclusion of counseling. None of these recommendations were based on solid research, however, and they did not seem to have as much agreement as those concerning the content and instructional techniques that we summarized previously. Yet some of these community college policies or practices may have a direct impact on the success of their developmental mathematics curriculum. For instance, professional development for developmental mathematics instructors or the location of developmental math (e.g., whether it is part of the mathematics department or in a separate developmental education department) may be highly correlated with the value that the institution places on developmental education in general. The absence of studies that can attest to a correlation suggests that this may be an area for further study. In the meantime, for our purposes it is instructive to summarize common practices in some of these program components.

The AACC conducted a survey of more than 1,100 community colleges, with a nearly 40-percent return rate (Schults 2001). Some highlights of their findings follow:

- Every college responding to the survey offered at least one developmental course. Math, reading, and writing were offered by 94 to 96 percent, and Adult Basic Education was offered by less than half.

- Of the institutions that responded, 33 percent of the faculty at public community colleges who teach developmental education classes were full-time, roughly equivalent to the overall proportion of faculty that are full-time.

- The majority, or 58 percent of responding institutions, required assessment of basic skills for all students. Many allow exemptions from these tests; 76 percent of those that allow exemptions use college entrance exam scores instead. Other criteria for waiver of the tests include high school grade point average (GPA), statewide high school exam scores, Advanced Placement (AP) scores, and transfer from another postsecondary institution.

- The most commonly used tools for assessing skills were a computerized test (63 percent) and a paper-and-pencil test (60 percent). Other measures included college entrance tests (36 percent), institutionally developed measures (24 percent), and state-developed measures (16 percent).

- A large percentage of the institutions—77 percent—set their own cutoff scores on the assessment tests, while the state sets the standards in the remaining 23 percent.

- Of the 58 percent of institutions that mandate assessment, 75 percent require placement in courses based on the testing. Of these, almost two-thirds set this policy, and the remaining one-third reports that the standards are set by the state.

- Developmental courses are predominantly offered within relevant departments (61 percent), while 25 percent report that developmental courses are housed in a separate developmental department.

- The median number of levels of developmental math offered by colleges is three. More levels of remediation were offered in institutions located in large cities, and enrollment in developmental education also was typically higher in these institutions.

- Three-fourths of the institutions offered only institutional credit (not toward graduation but counting toward full-time status for the purpose of financial aid) for all developmental courses, 5 percent offered degree credit only, and 5 percent offered no credit. The remaining institutions offered multiple forms of credit.

- Developmental courses in math had the highest median class size—25—of any other type of developmental class surveyed. For comparison, the median class size for both developmental reading and developmental writing was 20. However, almost two-thirds of the institutions report having a policy concerning limits to class sizes with 95 percent of these reporting that the state did not mandate such limits.

- Partly because of limits on federal student financial aid that a person may receive

for developmental education, almost one-quarter of institutions use various methods to limit the number of developmental courses a student may take. Of those, 20 percent increase tuition after students attempt multiple times to take developmental courses, 32 percent simply restrict students from taking additional developmental courses, 30 percent cease nonfederal funding, and 19 percent use other methods. Of those that set limits, 45 percent do so by state mandate.

- Slightly over half (56 percent) of institutions report using more than one measure to assess whether a student can transition out of developmental work. The largest percentage (91 percent) use successful completion of the developmental course for assessment.

- Almost half (45 percent) of institutions offered self-paced developmental courses to students, and 26 percent offered distance education for developmental courses.

- About 80 percent of institutions responding indicated that they sometimes or frequently use computers in instruction.

We turn now to a summary of our findings of community college practices that covers a number of additional topics, including specific textbooks and software.

Our Internet Survey of Syllabi and College Catalogues

Creating a new developmental math curriculum, or revising an existing one, involves numerous fundamental decisions: what material to cover; what texts to use; how many credits to confer per course and what types of credits to award; what, if any, software to use; what, if any, placement tests and cutoff scores to use; identification of the right delivery method for the student body concerned; and so on. Guidance for some of these choices can be found in our review of recommendations of content and pedagogy, as well as the AACC survey of practices, while some options will be dictated by institution or state policy, especially concerning the types of credit that can be awarded or the placement tests that can be used.

To supplement information in the review of the literature, and especially to provide guidance on some of these issues that were not covered elsewhere, we used the Internet to search community college developmental mathematics syllabi[6] and college catalogues for information on current practices. In particular, we researched which textbooks and software were being used, calculator policies, specific topics covered in introductory and intermediate algebra, prevalent instructional methods offered (i.e., distance learning, self-paced, and accelerated course options), the

[6] As we explain later, we confined our research to introductory and intermediate algebra. In this process, we discovered that a large number of colleges also included geometry in their developmental math requirements.

number of credits for each course, and whether the credits conferred were college or institutional credits only. We summarize these findings below.

Although this is not a scientific survey, the information that we gathered provides useful information relating to several basic pedagogical issues. Taken in isolation, these practices are not necessarily optimal, nor do they result in highly successful programs. As we discuss in a later section, the successful strategies that we found are a combination of these basic components in conjunction with other support systems, supplemental material and so on. However, combined with the recommendations in *Crossroads, Vision*, and others that we reviewed earlier, the information summarized here is a useful tool in structuring some basic parameters of a developmental math curriculum. *Vision,* for instance, noted the need for students to be able to use graphing calculators; our survey provides information as to which graphing calculator(s) instructors are using.

Methodology

We used the Google search engine (www.google.com) to search for online introductory and intermediate algebra courses in community colleges. We chose a sample from the first several hundred hits from our search; many had to be eliminated because they were not relevant to our purpose here.[7] We then searched the catalogues of the colleges included in our survey for additional information. Finally, we included information that was derived exclusively from the catalogue for two institutions in New York State because we were not able to locate an online syllabi in any two-year college in that state that met our criteria. We wanted to include New York because of its significant community college student population and to ensure an adequate northeast representation in our survey.

In total, we collected information from 32 community colleges, 97different courses, 105 different sections (the same course may have multiple sections, taught by different instructors or by the same instructor but using different approaches, and in some cases we sampled a number of sections of the same course) in 24 states. Of these, 44 courses cover introductory algebra exclusively (and 48 sections), 41 courses cover intermediate algebra exclusively (and 45 sections), seven courses (and sections) contain some significant geometry component, five courses (and sections) offer accelerated introductory and intermediate algebra[8], and seven courses (and sections) are not accelerated but offer a significant number of topics in both introductory and

[7] Reasons for exclusion included outdated syllabi, the course was offered at a high school or four-year college, there wasn't enough information in the syllabus, or the course was something other than Introductory or Intermediate Algebra, such as Linear or Abstract Algebra.

[8] We use the term "accelerated" to refer to courses in which material is covered in a shorter period of time so that some or all of the material that is normally covered in a second course in the sequence is covered in the first course.

intermediate algebra.

Since our focus in this study is on introductory and intermediate algebra, we summarize our findings only for the algebra courses that did not have a significant geometry component in table 4. In addition, because we reviewed so few accelerated (five) or combined (seven) courses, we do not include statistics for those courses in the table. Finally, some statistics refer to unique courses, and others to sections; the differentiation is noted in the table.

Common Pedagogy Used in Developmental Mathematics

In our sample, instructor-led instruction is the most prevalent instructional method. Only seven of the seventy-two sections (including accelerated and combined) were self-paced courses, of which four were self-paced distance learning courses. While all of the remaining sections are traditional instructor-led classroom instruction, this does not mean that all of these sections consist entirely of lecture; the use of group work, including presentations and projects, and work that is both inside and outside the classroom, is cited frequently. In addition, many instructors strongly urged the use of study groups for work outside the classroom. These practices resonate with the recommendations from the studies we reviewed previously—that faculty should make use of interactive learning and should promote collaborative work in the classroom. We will come back to this pedagogical tool when we discuss the colleges with promising practices in a later section.

Time on task is also an important component of the course for many instructors; several made recommendations concerning the amount of time that students should spend outside the class on reading the material, doing homework, working additional problems, or working on software associated with the text. The most common recommendation was two to three hours of outside work for each hour of class.

In addition, the most common number of credits these classes confer, which is also roughly equivalent to the number of hours the course convenes each week, is 3 or 4.

While the AMATYC guiding principles established in *Crossroads* state that mathematics must be taught as a laboratory discipline, our survey found that labs are used as a supplement to some, but not a majority, of developmental algebra courses; about one-third of both introductory and intermediate algebra courses offer a lab component. However, in some instances, we found discrepancies between the online catalog course description, online syllabus, and departmental description of the course. As an example, the online schedule for one course stated that it consisted of four hours of lecture, yet the syllabus notes that it is an instructor-facilitated self-

paced course. As a consequence, we cannot draw conclusions concerning the prevalence of labs used as a supplement to regular instruction, except that it seems likely that the use of labs in developmental algebra courses is not the prevailing practice.

Table 4: Selected characteristics from Internet sampling of community college algebra courses

Characteristic	Introductory Algebra	Intermediate Algebra
Number of unique courses	44	41
Number of sections	48	45
Number of syllabi	35	34
Lab is part of course[1]	37%	33%
Course offers distance learning option	45%	58%
Course requires calculator	41%	62%
Course confers college credit	28%	48%
Sections that are Self-paced	11%	9%
Number of courses by credit hours:		
2 credits	4	3
3 credits	22	19
4 credits	14	16
5 credits	3	2
6 credits	1	1

[1]This includes only those courses that are not solely distance learning, and for which we were able to determine whether there was a lab component.

Finally, about half of the introductory and intermediate algebra courses we surveyed offer a distance learning option, but fewer accelerated courses—only one in five—do so. Referring to the syllabi, we note that most, but not all, of these distance learning courses are computer based, either exclusively or with a supplemental text (we will discuss software later). It appears that relatively few distance courses are based on students using a textbook exclusively.

Calculator Policies

Instructors of intermediate algebra require calculators most often; almost two-thirds require them compared with fewer than half of the introductory algebra instructors. While not specifically required, an additional number of instructors recommended a calculator. Conversely, some specifically prohibited the use of calculators on tests, or only allowed them after a certain point in the semester.

In terms of calculator use, many instructors specified only the type of

calculator, such as scientific, business, graphing or, more generally, one that has logarithms or exponential functions or both, rather than a particular model. Recommendations were about evenly split between requirements or recommendations for scientific versus graphing calculators for both introductory and intermediate algebra. By far, the calculator recommended most often, when a specific one was recommended, was the graphing calculator made by Texas Instruments, the TI 83 or TI 83 plus; of the sixteen specific recommendations, all but one included this calculator. Several recommendations also included other Texas Instruments graphing calculators (TI 82, TI 84, TI 86); one recommended a Texas Instruments scientific calculator (TI 30X IIS), and one recommended a basic calculator from Casio, the Casio 300.

Textbooks Cited

Some of the most readily available information contained in these syllabi concerns the textbook. We identified thirty-four different texts, only ten of which were used in more than one college. A complete listing of the textbooks can be found in appendix A.

The most often cited publishers of texts used in these courses are Addison Wesley, Houghton Mifflin, McGraw-Hill, Prentice Hall, and Thomson Brooks/Cole. For each of these publishers, textbooks differ mostly by the edition or the title of the text rather than by author; one author(s) accounts for six different titles, two account for four each, and one accounts for three. Their popularity is attested to by the fact that most of these frequently cited texts are at least in their sixth edition.

Rapidly changing technology has made a discussion of textbooks incomplete without a description of the accompanying software and online tools. Most of the major college textbook publishers, such as those just cited, offer similar types of instructor and student resources with developmental mathematics texts. These tools and resources include:

- Online tutorials
- CDs and video learning aids for students
- Online gradebooks
- Online homework problems and management tools
- Online tests
- Student study plans for self-paced learning
- Online tutoring, via e-mail or interactive Web. Most also offer help via telephone or fax.

For reference, both Prentice Hall and Addison Wesley are part of Pearson Education, and, as such, they offer the same software and tutoring support. Their

developmental mathematics software includes MyMathLab, MathPro5, and MathXL. We will discuss MyMathLab in more detail in a later section. Their tutoring service is referred to as the Tutor Center, and is staffed five days a week, seven hours a day, by qualified college instructors (Pearson Education 2005).

McGraw-Hill uses MathZone software (McGraw-Hill 2005). In addition, the Assessment and LEarning in Knowledge Spaces (ALEKS)[9] software can be purchased in a package with any of its higher education textbooks, and some texts are written specifically for use with the software. For tutoring assistance, McGraw-Hill uses NetTutor.

The software used by Houghton Mifflin for several subjects, including developmental mathematics, is called Eduspace, and the publisher has partnered with Smarthinking for its online tutorial support (Houghton Mifflin 2005). Smarthinking is a company that provides online tutoring support to schools, colleges, libraries, government agencies, and textbook companies (Smarthinking 2005). Its online tutorial help in mathematics is available twenty-four hours a day, seven days a week.

Thomson Brooks/Cole offers a variety of online course management tools, including WebTutor and iLRN, but we were not able to locate any online or other tutoring support for students with any developmental mathematics textbooks (Brooks/Cole 2005).

Types of Software Used

Our review of online courses is not comprehensive enough to allow any conclusions about software used in instructor-led or distance learning developmental mathematics courses, except that we observe that the use of software is not pervasive; only about half of the syllabi noted the use of instructional software.

Instead, we use the survey results as an opportunity to briefly discuss some differences in the types of software available, and to shed some light on what may be common themes. In our discussion of promising practices, we provide more information concerning how particular software is being used as part of a number of successful strategies.

Before we present our findings, a brief discussion of the differentiating characteristics of the software is useful.

In broad terms, there are two general categories of software used: those

[9] ALEKS is online software designed for self-paced instruction. We will discuss ALEKS in more detail in a later section.

published by textbook publishers as a supplement to texts, as described above, and those offered as stand-alone courses for online, self-paced instruction. The most common of the latter that we found are published by PLATO and ALEKS, the only two noted in our survey. Carnegie Learning is another software that is fairly commonly used.

A number of theories of how people learn are at the heart of most of the self-paced instructional software. According to the ERIC Thesaurus, Intelligence Tutoring Systems are "computer-assisted instructional systems employing the principles of artificial intelligence to carry on dialogs with students and use student responses to assess learning" (ERIC 2005). In other words, the instruction is constantly modified to meet the individual learner's needs, by incorporating responses to questions on material covered to assess strengths and weaknesses, and modifying the approach and content where necessary.

As we noted, PLATO, which merged with Academic Systems in November 2003, is one of the more common online self-paced software programs. It offers two products at the postsecondary level: algebra I & II and interactive mathematics. The former is targeted at the skill level of sixth through twelfth grade; the latter is for grades nine through fourteen. Only Interactive Math was recommended by any of the colleges we surveyed, which, according to PLATO, covers pre-algebra, elementary algebra, intermediate algebra, and college algebra (PLATO 2005). The PLATO Web site contains hyperlinks to assessment reports or interviews with faculty in twenty-three community colleges that use this software.

ALEKS is an intelligent tutoring system developed by cognitive scientists and software engineers, with funding from the National Science Foundation (ALEKS 2005). ALEKS offers both beginning and intermediate algebra modules at the postsecondary level, as well as numerous other topics within mathematics. We will discuss ALEKS more in later sections.

Table 5 summarizes the software used in both introductory and intermediate algebra courses for all courses in which a specific software was noted, differentiated by whether the course was self-paced. As a reminder, of those listed in the table, all but ALEKS and PLATO are software associated with the use of a particular textbook, rather than stand-alone software.

Table 5: Software used for instruction in Internet sampling of community college algebra courses

Software	Introductory Algebra		Intermediate Algebra	
	Self-paced	Not self-paced	Self-paced	Not self-paced
ALEKS		1		1
HM3		1		1
MathCue		1		
MathPro5		1		1
MathXL		1		1
MyMathLab	1	5		7
PLATO Interactive Math	1	2	2	

Of the self-paced courses we included, two did not specify any software, three used PLATO, and one used MyMathLab. However, both ALEKS and PLATO, while designed for self-paced courses, were used about equally as often in courses that were not self-paced.

Because of the coordination between the textbook and software, it is not surprising that the most often recommended software for instructor-led courses was the software associated with the textbook. Largely reflecting the relative popularity of Pearson Education textbooks, MyMathLab was recommended more than any other software covered in our review. This is one piece of software we will be talking about in more detail in our next section.

Common Credit Type for Developmental Mathematics Courses

Only about one-quarter of colleges grant college credit for introductory algebra, and about half confer credit for intermediate algebra. The remaining colleges offer institutional credit only, which means that the credits count toward criteria for full-time status, and hence financial aid, but do not count toward graduation requirements.

Our survey showed consistency within a state, but not across states; statewide consistency may not, however, be unanimous. For instance, neither of the colleges that we surveyed in Florida grant credit for introductory algebra but both do for intermediate algebra, all three of the colleges in California grant college credit for both introductory and intermediate algebra, and none of the colleges in Texas or New York grant college credit for either one.

The issue of whether to grant college credit is complicated. Accreditation

standards are certainly a large driver of credit policy. But, more relevant to our purposes here, credit policies can pose significant challenges to developmental math students in satisfying all necessary graduation requirements. Differing mathematics requirements for graduation, in combination with the credit status of developmental math courses, mean that the requirements for two otherwise identical students with comparable math competencies can vary by two or more courses, depending on the institution they attend. As we discuss later, these requirements, regardless of the exemplary design of the developmental mathematics curriculum, can result in very different success rates.

We also found a wide variation in the number and types of developmental math courses offered across colleges. In browsing through online college catalogues, we noticed significant variation (a) in the lowest level of math offered, with some colleges offering basic arithmetic and others beginning the sequence with introductory algebra; (b) in the number of courses offered in a developmental math sequence, with variation depending on the actual subjects covered, such as whether geometry is required, or in the number of options offered for the same courses, such as whether accelerated courses are offered; and (c) in the approach taken within the same subject, depending on whether the student intends to major in the health sciences, elementary education, or business, for example. Our observations concur with the findings of the AACC's survey of common practices cited earlier—that is, that the median number of levels of developmental mathematics offered is three, but certainly there are a number of institutions that provide far more options.

Subject Matter Covered

Do faculty who adopt textbooks determine their content because of their unique demand for textbooks, or, conversely, is it textbooks that determine their content because of their unique supply, or is it some combination of both? Regardless of which one or which combination drives the content, we found that the topics covered in the textbooks listed in appendix A are all very similar and that they coincide with the topics as outlined by instructors on their syllabi.[10] Further, they are in general agreement with the knowledge content recommended by the four major research reports that we summarized earlier. The broad topics covered in introductory algebra follow:

- The real number system (e.g., ratios, fractions, percentages, decimals);
- Linear equalities in one and two variables;
- Linear inequalities in one and two variables;
- Systems of linear equations;
- Systems of nonlinear equations;

[10] The table of contents for texts is often available on the publisher's Web site.

- Exponents;
- Polynomials;
- Factoring;
- Rational expressions;
- Roots;
- Radicals;
- Quadratic equations;
- Graphing.

Some introductory algebra texts also add a section on solving problems, although less so than in texts covering intermediate algebra. In addition, some instructors specifically noted that they cover such topics as coordinate or plane geometry (although we didn't find this covered in the texts), scientific notation, calculator use, and trigonometry (also not covered in any of the texts).

In general, intermediate algebra texts cover much of the same material as the introductory texts, but at a higher level. However, most do not include the real number system. Additional topics in intermediate algebra include:

- Functions
- Conic sections
- Logarithms
- Sequences, series, binomial theorem.

Other Factors Noted in Syllabi

We did not document other factors specifically in our Internet search of syllabi and college catalogues, but in our research we found a couple of noteworthy practices that are most likely indicative of fairly common practices. In particular, a majority of instructors had explicit attendance policies. These policies were established by the institution, the department, the individual instructor, or, in some cases, the state, especially as the policy pertained to all developmental education students. No consistent policy emerged, and variation in allowable absences ranged from two to ten days, or, in terms of percentage of days, from 10 to 25 percent. Penalties for absences in excess of these maximums ranged from an automatic withdrawal or automatic failure, to either of these at the discretion of the instructor. This practice, combined with the fact that we found only a small fraction of developmental courses that were offered via distance learning, may be indicative of a general consensus that developmental mathematics is best taught in instructor-facilitated lecture format, and that students do not learn the material well when left to learn it, for the most part, on their own.

We also found, either in the syllabus or by looking at the specific college Web

site, that virtually every college has a math learning lab or tutoring services, or both, for students enrolled in developmental math. Tutoring services vary, ranging from unlimited tutoring to a maximum number of hours per week. In most cases, the tutoring is free and may be provided by fellow students, paid professionals, or the instructors themselves. Variation also exists in the types of support available in the lab, including videos of the instructor's lectures, other tutorial videos or CDs, developmental math software, and access to online help.

We turn now to a discussion of some characteristics of adult learners in community colleges in general and those in developmental studies in particular.

Community College Survey of Student Engagement: Characteristics and Challenges of Developmental Students in General

Community college students face a number of challenges that go beyond those presented by academic rigor. For some, especially recent high school graduates, college attendance may present few competing family pressures, but adjusting to new friends, a less structured academic environment, and the financial costs of college may be fairly challenging aspects of college life.

Older students may face these and other challenges, such as child care, mortgages, employment, and an erosion of knowledge and skills attained years before in high school. Even the best pedagogy, taught by the best instructors, using the very best technology available may not be able to successfully move students through developmental mathematics and into college-level math courses if the students they teach face overwhelming challenges outside the classroom.

The CCSSE provides an excellent resource for us to gauge certain parameters of developmental education in community colleges, in general, and especially some of these challenges of developmental education students.

CCSSE was established in 2001 as a project of the Community College Leadership Program at The University of Texas at Austin. CCSSE works in partnership with the National Survey of Student Engagement (NSSE), an instrument that is administered to four-year colleges and universities. However, CCSSE is designed to address the specific issues and concerns of two-year colleges (CCSSE 2004).

CCSSE administers the survey annually nationwide; 93 colleges in 31 states participated in the survey in 2003, whereas over 140 colleges participated in 2004. The data are made available to the public on the CCSSE Web site.

Because participation in the survey is voluntary, the CCSSE survey is not a

scientifically based, nationally representative sample of colleges. However, CCSSE uses a stratified random sample to survey within each college to ensure a within-college representative sample, and the national surveys include community colleges of all sizes, ranging from fewer than 5,000 students to more than 15,000. The colleges also represent a cross section of socioeconomic conditions in terms of geography (about half of the colleges are located in urban areas and one-quarter each from rural and suburban areas), students' ages (ranging from seventeen to over sixty years age), and their racial and ethnic backgrounds. Therefore, we believe the survey's results provide us with, at least, insightful and, at best, statistically valid observations about certain characteristics of developmental courses and the challenges these populations face around the nation.

Our Data Query

In addition to overall survey findings, data queries can be performed separately by student or institutional characteristics, or both. For our purposes, we differentiate between the responses by (1) whether the students were defined as "developmental" (i.e., have enrolled in, or are planning to enroll in, developmental reading, writing, or mathematics courses)[11] and (2) the student's age. We chose the latter distinction because we are interested in addressing the specific concerns of adult learners who are transitioning from an ABE course of study, which usually implies a somewhat older cohort of students.[12] CCSSE defines "traditional aged" students as those under the age of twenty-three for the 2003 survey and under age twenty-two for 2004. Therefore, we have four categories of students: (1) traditional age/developmental, (2) nontraditional age/developmental, (3) traditional age/nondevelopmental, and (4) nontraditional age/nondevelopmental.

We impose two additional restrictions on the data: (1) students with fewer than thirty credits and (2) students who are seeking credentials. The credit restriction confines the results to students who are generally in their first year of study at the college, when they are most likely taking developmental courses. This approach will allow us to infer some characteristics of developmental education in general, especially as their responses are compared with nondevelopmental students with the same number of credits. However, significantly more of the developmental students responding to this survey require developmental mathematics than need reading or writing. For instance, over 88 percent of both age groups will be or are enrolled in developmental mathematics. In addition, 60 percent have already completed some developmental math courses, compared with fewer than 40 percent for either reading or writing. As a consequence, these responses are heavily weighted toward developmental mathematics experiences.

[11] It is not possible to select only those students in developmental mathematics.

[12] Fifty-nine percent of students in state-sponsored ABE programs are over the age of twenty-four (Welch and DiTomasso 2004).

We further confine the survey results to students who are seeking credentials as an additional control for student characteristics that are related to either engagement, persistence, or both, and to best reflect the education goals of the targeted beneficiaries of our research.

We selected various questions that provide some indication of the curriculum and strategies used in developmental courses, as well as the priorities, special needs, or concerns of developmental students, especially older ones. By including responses that are differentiated by age and developmental education status, we can determine whether certain factors are especially important for all developmental students regardless of age or only for older developmental students. As a reference point, 71,961 respondents were credential-seeking students with fewer than thirty credits. Of these, 17,192 were nontraditional/developmental, 13,951 were traditional/nondevelopmental, 22,643 were traditional/developmental, and 18,175 were traditional/nondevelopmental students. Reflecting the national trend, this translates to 55 percent of students with less than thirty credits requiring developmental courses, and of these, two out of five were older students.

Appendix A summarizes responses to a number of questions from the survey. We discuss some of the most interesting findings here.

Educational Attainment and Aspirations

Educational attainment, regardless of developmental education status, may influence both success and retention[13] for a number of reasons. On one hand, developmental students who have previous postsecondary experience may be more likely to have been exposed to the material covered in developmental classes than those with just a high school degree. In such cases, the material is a review rather than a first-time introduction. On the other hand, longer lapses in time between postsecondary education episodes may be correlated with lower retention of the material. If age and the time since last formal schooling are correlated, older developmental students with prior postsecondary education experience may not have any advantage over younger developmental students who recently completed high school, and older students with no postsecondary education may be at the greatest disadvantage. However, we are not aware of research that controls for these simultaneous factors on the ability to learn developmental mathematics or to persist in postsecondary education.

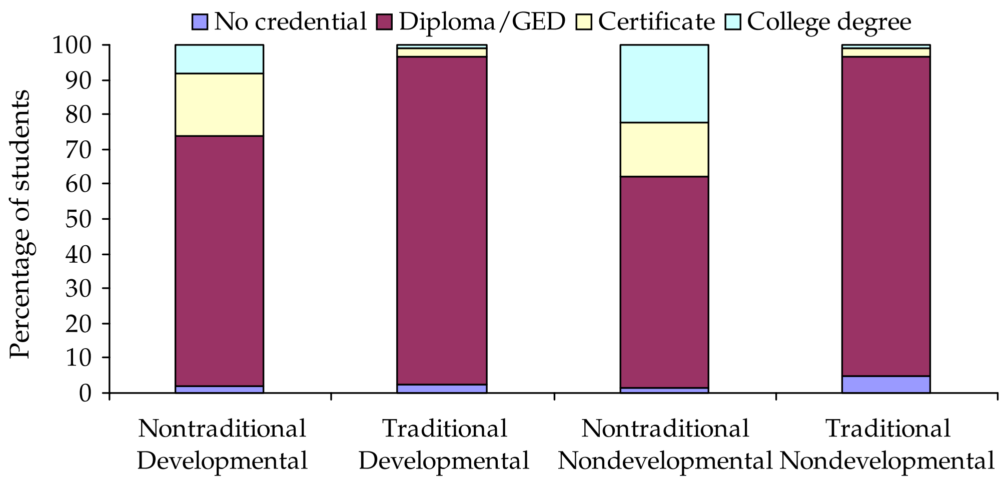
Educational aspirations also have an effect on persistence and success. For example, students beginning their education at a public two-year college whose goal

[13] Course retention is defined as remaining enrolled in the course through the semester; retention in the college refers to continuous enrollment from one semester to the next.

is to earn a certificate are more likely to attain that goal at the institution where they started than are those whose goal is to earn a two-year degree, in part because a certificate program is shorter in length (NCES 2000).

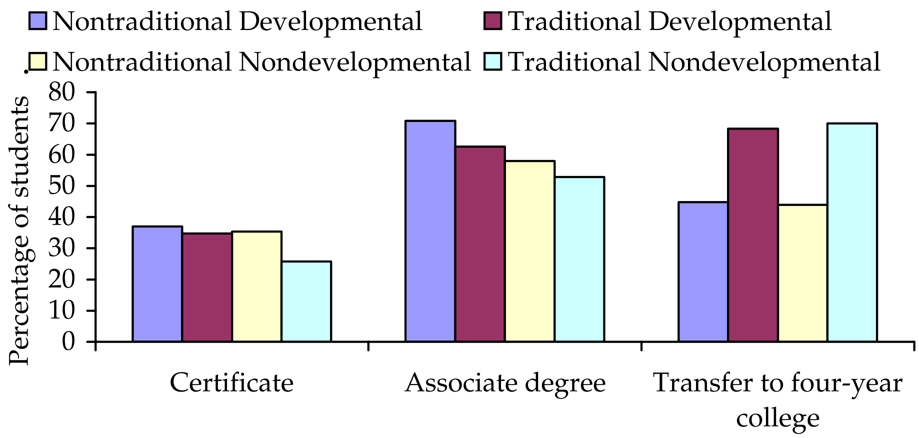
Figure 1 shows the percentage of respondents in each category that indicated the highest education credential they possessed. Not surprisingly, compared with younger students, older students are more likely to have some education beyond high school regardless of developmental education status. Of this older age group with postsecondary education, however, developmental students are more likely to have a vocational or technical certificate, whereas nondevelopmental students are more likely to have any college degree (including an associate degree or higher).

Figure 1: CCSSE findings: Highest credential possessed



Educational aspirations also differ by age and developmental education status. Figure 2 displays the percentage of students indicating which academic credential is their primary goal in attending the college. The categories are not mutually exclusive; both obtaining an associate degree and transferring to a four-year college can be simultaneous goals.

Figure 2: CCSSE findings: Primary educational goal



Perhaps because nontraditional age students, regardless of developmental education status, are more likely to have a postsecondary credential, they are far less likely to have a primary goal of enrolling in a four-year college. This is consistent with responses to the question concerning how likely it is that the student would withdraw from the college in order to transfer to a four-year college; traditional aged students are over 50 percent more likely than nontraditional aged students to withdraw for this reason, across developmental education status. In general, then, older students tend to have more college experience and lower postsecondary education goals than younger ones regardless of developmental education status.

We note these differences because, as we cited previously, research indicates that students with lower academic goals are more likely to realize them. That would imply then that, all else equal, nontraditional developmental students would tend to have lower dropout rates than younger ones. However, as we discuss next, all else is not equal.

Challenges Developmental Education Students Face

We turn now to some of the particular challenges that various students face in completing their education goals, especially in terms of financial and family pressures. Among other sources, the survey asked whether public assistance or grants or scholarships were a major source to pay tuition at the college. Figure 3 illustrates their responses.

Older developmental students are far more likely to finance their education with grants, scholarships, or with public assistance than any other category of

students, including older nondevelopmental students. Since these sources of financing their education are based on financial need, we conclude that older developmental students have the greatest need for financial aid of the four groups of students.

Even with these grants, older developmental students are more likely to withdraw from college for financial reasons than any other reason cited, as figure 4 illustrates. In this figure, we illustrate the percentage of students who responded that they were "very likely" to withdraw from a class or college for any of a number of reasons (other possible responses were "not likely," "somewhat likely," or "likely").

Work, family, and financial challenges are greater concerns to older students than younger students regardless of developmental course work status, but older developmental students appear to be the most challenged by these factors. The exception is dropping out due to being academically unprepared; younger developmental students are slightly more likely to withdraw for this reason than any other type of student.

Figure 3: CCSSE findings: Sources of college financing

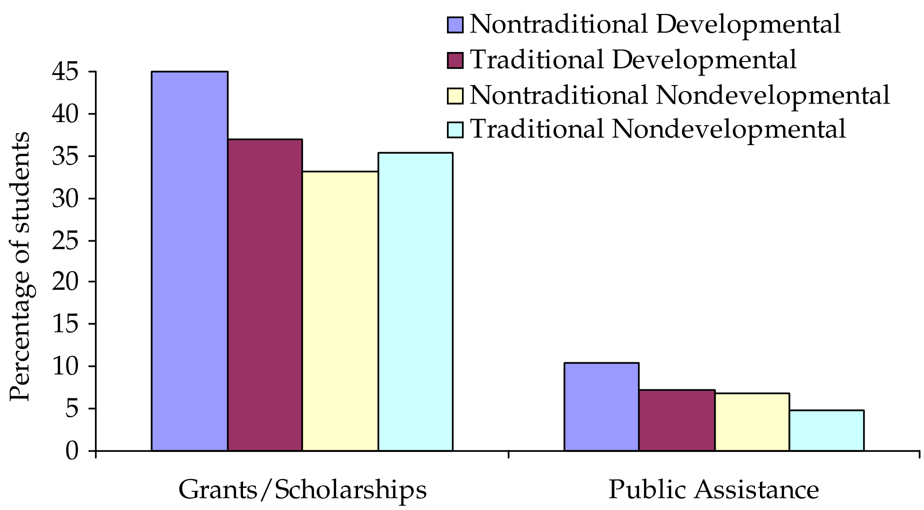
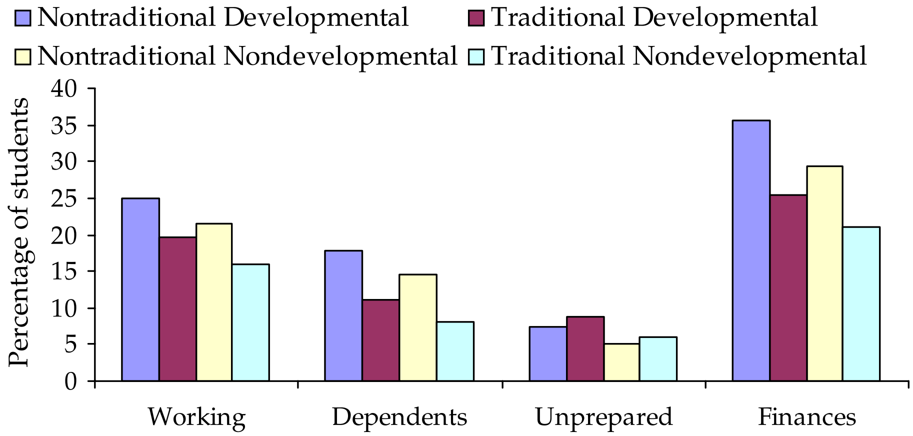


Figure 4: CCSSE findings: Likely reasons to withdraw



Combining the responses of likely and very likely to these questions, and ignoring age categories, we find that developmental education students face far more challenges than their nondevelopmental peers; they are 45 percent more likely to withdraw due to being academically underprepared, 18 percent more likely due to financial considerations, 25 percent more likely due to caring for dependents, and 16 percent more likely due to working full-time.

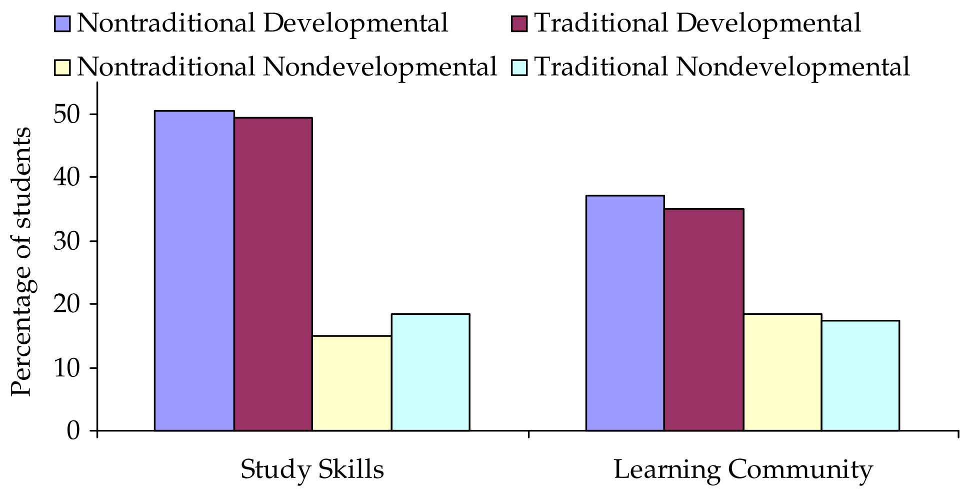
These findings point out the importance of understanding the population of students served when considering whether one developmental mathematics curriculum is especially successful. In particular, it is not simply pedagogy and course content that determine pass rates and persistence in developmental mathematics courses, but a variety of factors that also take into account the characteristics and challenges of the unique populations being served by the institutions. We will return to this point later.

Prevalence of Developmental Education Students Enrolling in Learning Communities and Study Skills Courses

The next set of responses pertains to the academic experience itself. CCSSE cites several research findings that indicate that both study skills courses and learning communities have a positive impact on performance and retention regardless of developmental education requirements. In figure 5, we compare the percentage of students indicating that they have been, or plan to be, enrolled in either a study skills course or a learning community. Little difference exists in the responses to either of these types of courses based on the developmental student's age; all developmental students are far more likely to take both courses than are nondevelopmental students. Study skills courses appear to be more prevalent among developmental

students than learning communities; fully half have taken or plan to take the former compared to slightly more than one-third who have or plan to take the latter. There does not appear to be a difference in enrollment for nondevelopmental students; both study skills and learning communities are pursued by slightly less than 20 percent of these students.

Figure 5: CCSSE findings: Study skills and learning communities



Students' Assessment of Impact of Education on Critical Thinking and Developing Career Goals

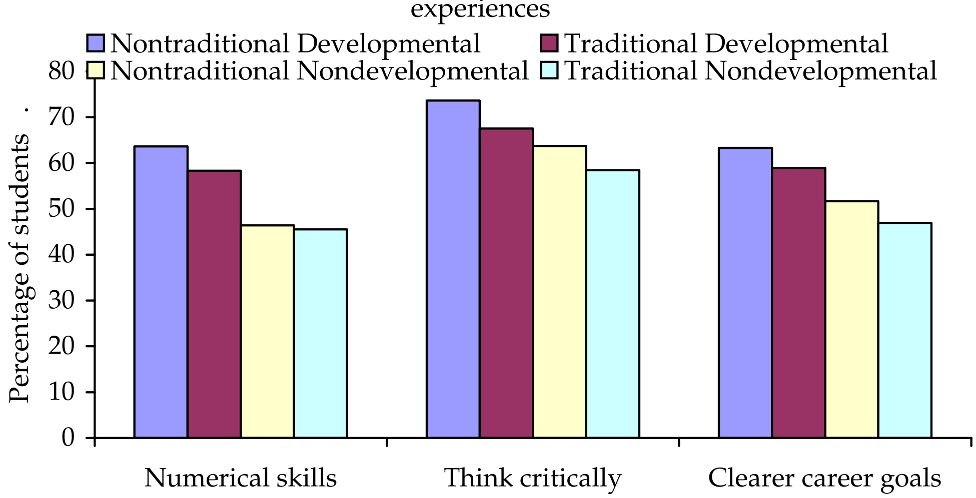
Several questions are included in the survey that pertain to academic challenge. We focus on those relating to developing the ability to think critically and analytically, to solve numerical problems, and to develop clearer career goals. We include the first two questions because our literature review of the necessary skills and abilities to pursue college-level mathematics indicated the importance of both of these. Career goals are included because a number of studies, including those cited by CCSSE, have concluded that students are more engaged and persist at higher rates if they have clearer career goals. Given the same curriculum, we wanted to see whether the perception of all three of these differs according to the age of the student. The questions posed in the survey asked the respondent to indicate "How much has your experience at this college contributed to your knowledge, skills, and personal development in [the three above points]." In figure 6, we illustrate the sum of respondents who answered either "quite a bit" or "very much" in each of these three areas (the remaining categories were "very little" and "some").

Many more developmental students, regardless of age, responded that their

experiences contributed significantly to critical thinking, numerical problem solving, and developing clearer career goals than did nondevelopmental students. And across all three questions, more older than younger developmental students responded positively.

Again, it seems likely that this difference between developmental and nondevelopmental students is due to the nature of the courses they take. However, since it is likely that developmental students of all ages are enrolled in similar developmental courses, the difference in perception by age for developmental students is difficult to explain, except perhaps that these responses indicate that the perception of enhanced knowledge and skills is in some measure a function of the age and maturity of the learner.

Figure 6: CCSSE findings: Significant contribution of academic experiences



The Value of Student Services to Developmental Students

The last topic of interest to emerge from this study is the value that students place on student services. The survey is quite valuable in providing information about which types of support all students require, particularly for certain subpopulations, such as developmental or older students.

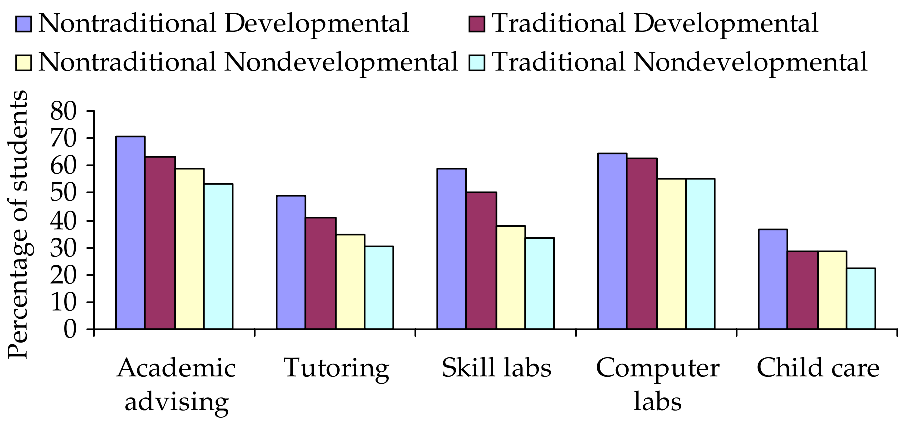
The survey asked students to indicate how important various services are, and provided the following three response choices: "not at all important," "somewhat important," and "very important." Figure 7 shows the percentage that responded "very important" to academic advising and planning, peer or other tutoring, skill

labs (e.g., writing, math), computer lab, and child care.

Developmental students rated all of these services more important than nondevelopmental students did, and within this group, older students found them more important than younger ones. The most important service for most categories of students was academic advising; the exception is traditional nondevelopmental students who rated computer labs as slightly more important. For the other groups, computer labs ranked as a close second to academic advising.

It is not surprising that tutoring and skill labs are far more important to developmental than to nondevelopmental students. For example, 43 percent more older developmental than older nondevelopmental students indicated that tutoring was very important, and 50 percent more younger developmental than younger nondevelopmental students indicated that skill labs were very important.

Figure 7:CCSSE findings: Very important services



Child care is especially important to older developmental students; over one-third of them indicated that child care services were very important to them. However, older nondevelopmental students were equally as likely as younger developmental students (who are far less likely to have children living with them) to rate it as very important. In other words, older nondevelopmental students are only slightly less likely to have children living with them than older developmental students (appendix B), yet child care is not nearly as important to them. This lends additional support to the observation made previously that older developmental students are faced with greater family and financial challenges than other types of students, including those with dependents.

In summary, the CCSSE survey yields a number of interesting observations

concerning the current practice of developmental education in these institutions, and the unique needs of students who are enrolled in developmental courses, especially older students. The most important of these are:

- Older students, regardless of their developmental education status, tend to have more postsecondary education than younger students, and their primary education goals are more likely to be attaining an associate degree than enrolling in a four-year college. Conversely, younger students are more likely to have enrolling in a four-year college as a primary goal than any other goal.

- Compared with their nondevelopmental peers, developmental students in general, and particularly older ones, are more likely to finance their college education with grants or public assistance. Despite this, they are more likely to withdraw from college because they face family and financial challenges. Financial concerns outweigh all other reasons, including being academically unprepared, and they are 18 percent more likely than nondevelopmental students to drop out due to financial reasons.

- Study skills appear to be a fairly prevalent component of developmental education courses. Half of all developmental students have taken, or plan to take, a study skills course. Taking advantage of learning communities is less common for developmental students; about one-third of them participate in an organized learning community. Nondevelopmental students rarely either take a study skills course or participate in learning communities.

- Regardless of age, a majority of developmental students (and significantly more than nondevelopmental ones) respond that their course work has contributed to their knowledge and skills in solving numerical problems and thinking critically and analytically, both of which are important skills in preparing for college-level mathematics.

- Older developmental students require more services than younger developmental students, and developmental students as a whole require more than nondevelopmental students. Especially important to developmental students are academic advising, computer labs, and skill labs. Less than 50 percent of developmental students feel that tutoring or child care are very important services.

PROMISING PRACTICES IN COMMUNITY COLLEGES

Our goal in the second phase of this project was to find a number of successful community college developmental mathematics programs so that we could document their strategies and draw upon lessons learned. One of the first steps in this process was to define precisely what we meant by (a) success and (b) developmental mathematics.

For our purpose, success is defined as the completion of a developmental mathematics sequence and the passing of a first college-level math course. We capture this concept with the following metric: the number of students that enrolled in the first course in a developmental math sequence that subsequently receive a "C" or better in a first college-level math course, divided by the number of students who enrolled in the first course in a developmental mathematics course sequence. Since the denominator in this metric includes all students who enroll in the first course in the sequence, even if they subsequently withdraw from that or any other course in the sequence, this metric accounts for success within each course, as well as persistence in both the mathematics sequence and in the college itself.

Although the definition of the success metric is straightforward, our research of successful programs revealed a number of practical difficulties in applying the definition consistently across institutions and across states. We describe these difficulties and how we resolved them below.

Issues Related to the Metric

The first issues that we discuss here were fairly easy to resolve by modifying our metric. In particular, community colleges have different starting points for developmental mathematics. Some community colleges start the developmental mathematics sequence with basic arithmetic, while others begin at the basic algebra level. In addition, institutional policy and state laws differ in college-level math prerequisites. For instance, in addition to the more common requirement of proficiency in high school algebra, which typically includes a two-semester beginning algebra-intermediate algebra course sequence, some states require all degree-seeking students to be proficient in geometry before enrolling in college algebra. Additional course requirements, all else equal, mean that these institutions are likely to show a lower success rate, as we have defined it.

Colleges also differ in their definition of a first-college level math course. Some colleges award college credit for intermediate algebra, while others do not. Further complicating matters is the fact that the choice of a first college-level math course frequently depends on the student's intended field of study. For instance, some colleges require different college-level math courses for science majors, business

majors, elementary education majors, and those in health care fields. These courses typically vary in rigor, which means that the overall success in otherwise similar colleges would vary based on the distribution of students within these various major fields of study.

In order to have a measure of success that could be applied more consistently across institutions, we needed to refine our definition. Since the primary beneficiaries of this research are ABE programs, we turned to the General Equivalency Diploma (GED) for guidance as to the most likely first developmental mathematics course recent ABE graduates would be required to take. While we could not identify any published statistics that indicated precisely what level of developmental mathematics that is, we chose basic algebra as the standard for the following reason. The topics covered in the new GED test, published by the American Council on Education (ACE), changed in January 2002 for all disciplines. The math topics now include measurement, algebra, geometry, number relations, and data analysis, with a greater emphasis placed on data analysis and statistics in the new test. ACE established passing criteria for the GED as a minimum score of 410 on each test component and an average of 450 overall (out of a possible total of 800 points), which most U.S. jurisdictions use as a passing score requirement (American Council on Education 2004). While a score of 410 out of 800 does not necessarily mean that a new GED recipient has obtained sufficient math skills and abilities to bypass a beginning arithmetic course, we suspect that it would be sufficient in most cases to begin with introductory or beginning algebra. In addition, one college indicated to us that about two-thirds of students with a GED do place into this level of developmental mathematics.[14]

Therefore, we refined our definition of success to include passing grades and persistence through a three-course sequence to begin with beginning algebra, to progress to intermediate algebra, and to conclude with college algebra or a comparable course.

Other issues arose in our search of successful programs that must also be considered and that are not so easily resolved. As our discussion of the CCSSE survey results indicated, academic performance and content mastery are not the only reasons students don't succeed in developmental math or don't persist in taking a first college-level course. The CCSSE survey results highlight the fact that colleges that serve a disproportionate number of at-risk students—such as single parents, and those economically disadvantaged—most likely have a lower success rate because these students are more likely to drop out of college. It is difficult, then, to determine success rates in isolation of the populations enrolled.

[14] University of New Mexico-Valencia (Shiplett 2004).

Measuring persistence uniformly over varying circumstances is another major challenge. The length of time each institution tracks students varies, sometimes through only one academic year, or as long as four years. Some research we reviewed indicated that it is important to take higher-level math courses consecutively, without taking any time off in between courses. The longer students are tracked, the lower the success rate of those who ultimately do take a course, again biasing the metric.

Reported data on success and persistence also often suffer from a lack of detailed information about how the statistics are calculated. What may appear as minor differences in the populations included can actually have a significant impact on the overall metric of success. For instance, success rates in a particular course or a sequence of courses may exclude students who withdrew from the course in the denominator (and typically a "C" or better is required for success). Even if withdrawals are included, differences exist in how institutions define withdrawals. Some institutions only record a withdrawal if it happens after the first week or so of classes, some longer. The variance is measured in weeks, creating an uneven playing field when comparing metrics across institutions.

Finally, we have found that few colleges have comprehensive statistics on their student enrollments, grades in individual courses, persistence from one semester to another and through various disciplines, and in almost all cases, across different branches of the same community college system, let alone to other colleges within or out of state. The latter is especially problematic because in many states, developmental education in public colleges is authorized at community colleges only; a large number of four-year college students will temporarily enroll in a two-year college to begin their developmental math sequence and complete it, especially the first college-level course, at their four-year institution.

To illustrate the potential magnitude of the effect of these factors on our metric, we list the states with the highest (greater than 50 percent) and lowest (less than 30 percent) graduation rates for less-than-four-year colleges in table 6.

Disentangling the reasons why almost 400 percent more students graduate in Alaska than students in New Mexico is difficult and most likely reflects all of the reasons we have outlined here, especially differences in populations served, postsecondary education policies, and the ability to accurately track student progress. Certainly, then, these same factors would have a similar effect on the reporting of success rates in developmental math courses.

Table 6: Graduation rates at less-than-4-year Title IV institutions for the cohort year 1999

Less than 30%		Greater than 50%	
State	Graduation rate	State	Graduation rate
Alabama	21.9	Alaska	76.8
Delaware	22.1	Arizona	56.3
Hawaii	27.2	California	54.2
Maryland	25.3	District of Columbia	65.2
Michigan	29.3	Pennsylvania	52.3
Mississippi	25.8	South Dakota	61.0
New Mexico	16.2	West Virginia	56.1
North Carolina	23.6	Wyoming	52.3
South Carolina	19.1		

Source: NCES 2004 (c) table 40.

Our Methodology

Given our more narrowly defined metric of success, and bearing in mind the difficulties in making direct comparisons across institutions, we approached our search of successful programs in a number of ways. First, we searched the Internet for institution-level metrics of success in developmental mathematics or developmental education in general. Mostly this involved searching for reports from institutional research departments in individual colleges. We also looked at state Web sites for reports.

In addition, we searched awards granted to institutions for developmental studies or developmental mathematics such as the League for Innovation in the Community College Innovation of the Year, AMATYC Input Award, Policy Center on the First Year of College Institutions of Excellence, and MetLife Foundation Initiative on Student Success Best-Practice Colleges.

Our next step was to send an email to chief executives in the governing body of community colleges in virtually every state,[15], requesting recommendations of colleges that, in their view, had exemplary development math programs. Of the state executives contacted by email, we received responses from sixteen. We also received responses from twenty of the forty-seven community colleges we contacted, yielding a higher response rate than for chief executives.[16] In addition, a message was posted

[15] We did not identify one for Michigan, New Hampshire or Rhode Island.
[16] A complete list of the contacts that we made is available on request.

to the AMATYC listserv in August 2004 requesting recommendations of exemplary programs, to which we received four responses, and a message was posted to the Math Special Professional Interest Network (SPIN) section of the National Association for Developmental Education (NADE), which did not elicit any responses.

Summary of Success Rates

First, as a point of reference, we note findings from the 2004 National Community College Benchmark Project (NCCBP). Johnson County Community College worked with eleven other colleges and a representative from the League for Innovation in the Community College to develop the first benchmark of community college practices, which was administered in 2004, with a total of 97 institutions participating (Johnson County Community College 2004).

Their definition of success in a course incorporates retention, as does ours; it is the number of students receiving a "C" or better, divided by the number of students enrolling in the course. The median success rate for students in developmental math courses for the 97 colleges responding to the survey was 58 percent, and the median success rate for the first college-level math course for students who completed all of their developmental math course requirements by fall 2001 and who enrolled in a college-level math course within one year was 61 percent.[17] Even though these statistics include developmental courses that we are not including in our research, such as basic arithmetic and geometry, and they are not differentiated by course, we find them useful in providing us with a general notion of the magnitude of the success we should expect from an "average" developmental math program. We use these results to estimate what a reasonable metric of success, as we define it, would be. In particular, if we assume that of every 100 students who enroll in beginning algebra, 58 receive a "C" or better, and that all 58 then enroll in intermediate algebra, then we expect approximately 58 percent of these, or 34, will receive a "C" or better in intermediate algebra. Again assuming that all 34 enroll in college algebra, and that 61 percent of these will receive a "C" or better, leaves us with a total of about 21 of the original 100 who ultimately receive a "C" or better in college algebra, or a 21-percent success rate, as we have defined it. This is actually an upper bound since certainly fewer than 100 percent of students who pass beginning algebra subsequently enroll in intermediate algebra. Likewise, not all students who pass intermediate algebra enroll in college algebra. Still, this provides us with a level of magnitude for gauging success.

In addition to this estimate, we gathered statistics from published reports that contained any of these various metrics so that we could define a range of typical success rates. In table 7, we report on the statistics that we found that pertain to

[17] Source: Jahnke 2004.

either success in individual developmental math courses, any developmental math course, or in a first college-level math course for students who completed a developmental math sequence. Some of these statistics are summarized for all community college students in the state,[18] and some are by individual institution.

Table 7: Measures of success as defined in this study

State	College	Success
AL[1]	University of Alaska at Fairbanks	17% enrolled in developmental math course in fall 1999 passed 100-level math course by spring 2002
AR[2]	Northwest Arkansas Community College	Spring 2003 college algebra pass rate of students who took intermediate algebra first: 70% (slightly higher than those who directly enrolled in college algebra)
CA[3]	Statewide	53% of students in developmental math courses in fall 2003 received a "C" or better, includes all students receiving any grade, including withdrawals
KS[4]	Statewide	Fall 2001 pass rate in first college-level math course: 59.9% of developmental students. Pass rate of intermediate algebra: 55.8%
NM[5]	Statewide	Fall 2002 pass rate in college-level math: 62% of developmental students, 66% of nondevelopmental students
PA[6]	Statewide	Fall 2000 pass rate in first college-level math course: 59.8% of developmental students, 64.7% of non-developmental students
VA[7]	Piedmont Valley Community College	21% of students enrolled in developmental math in fall 2000 had passed at least one college-level math course by 2003

[1]Source:University of Alaska 2004.
[2]Source:Northwest Arkansas Community College 2004.
[3]Source:California Community College Chancellor's Office 2004.
[4]Source:Kansas Board of Regents 2004
[5]Source:New Mexico Association of Community Colleges 2004.
[6]Source:Pennsylvania Commission for Community Colleges 2004.
[7]Source:Piedmont Valley Community College 2004.

While we found numerous additional statistics, we narrowed our selection to include only community colleges, and only those that most closely matched the

[18] Results for individual colleges are available for California, New Mexico, and Pennsylvania by going to the Web site noted for each.

measures of success that we are concerned with here; those that did not include withdrawals in the denominator were eliminated, as were those that did not specifically pertain to success in developmental math courses or college-level courses pursued by developmental math students.

These published metrics cover a number of milestones, but they lend support that our estimate of a typical success rate, as we have defined it, is in the range of 17 to 21 percent; that the pass rate in a first college-level math course for developmental students who enroll in such a course is between 60 to 70 percent; and that a typical pass rate for individual developmental math courses is about 53 to 58 percent.

Other Selection Criteria

As we noted, the success of a particular developmental mathematics program is a function of an array of factors that are often heavily weighted toward challenges that are unrelated to the courses themselves. That is why we relied on recommendations of key community college administrators, peers, and organizations that have acknowledged institutions for the success they have had in the face of unusual challenges. We also sought to include colleges that represented a wide spectrum of student populations, especially in terms of race/ethnic composition and socioeconomic conditions. We turn now to the colleges selected for this study.

Colleges Chosen for Their Successful Strategies

The following colleges were selected for their promising developmental mathematics programs:

American River College, California
Chandler-Gilbert Community College, Arizona
Community College of Denver, Colorado
De Anza College, California
Green River Community College, Washington
Miami Dade College, Florida
Mount San Antonio College, California
Northwest Vista College, Texas
Onondaga Community College, New York
Zane State College, Ohio.

These colleges serve populations that differ in age, socioeconomic conditions, academic aspirations, education credentials, urban/suburban/rural setting, geographical location, and racial/ethnic composition. Given the particular challenges of these populations, each college has implemented comprehensive strategies to address the needs of its developmental education students specifically, and the entire student body in general, resulting in promising results for their students. It is

important to understand, however, that none of these colleges has conducted scientific experiments to determine whether, or which, specific strategies enhance the success of the students. As we noted in our review of the literature, those types of studies are rare. Instead, we have included these colleges because they have noteworthy practices that appear to have had a positive impact on the success of their developmental math students in particular.

In addition to valuable insight into new and innovative strategies, we will see that there is a consensus in many aspects of their programs—a fact unknown to us before we made the selection. This finding provides us with a growing body of evidence that certain practices tend to be associated with higher success. We will discuss these common practices later.

Before we discuss the individual strategies employed by each college, we compare some of the characteristics of these colleges and the populations they serve.

Comparison of demographic characteristics

In figure 8, we illustrate the differences in the race/ethnicity of the student body served.[19] The race of the remaining students is unknown, ranging from none to as high as almost 19 percent in Onondaga Community College. For comparison, we include the national average of all two-year colleges.[20]

The Community College of Denver and Miami Dade College both serve a fairly large population of African Americans and Hispanics; Miami Dade's student body comprises almost two-thirds of the latter. Mount San Antonio College and Northwest Vista also serve a large Hispanic student body. In contrast, De Anza College and Mount San Antonio, both in California, serve a large Asian/Pacific Islander population, and the Community College of Denver, De Anza College, and Miami Dade College all serve a disproportionate number of non-resident aliens. Green River Community College and Zane College serve populations that are at least 73 percent Caucasian (the national average is 64 percent).

These institutions also vary significantly in the size of the student body served, ranging from 1,700 students at Zane College to over 58,000 in Miami Dade College (figure 9). They also vary in their location; the Community College of Denver and Miami Dade College are both in large urban settings, Chandler-Gilbert Community College's campuses are in rural or suburban locations, Zane State College is in a small town, and the remaining colleges are in suburban settings.

[19] Source: IPEDS 2005.
[20] Source: Hoffman et al. (2003).

Figure 8: Race/Ethnic composition of students in selected colleges

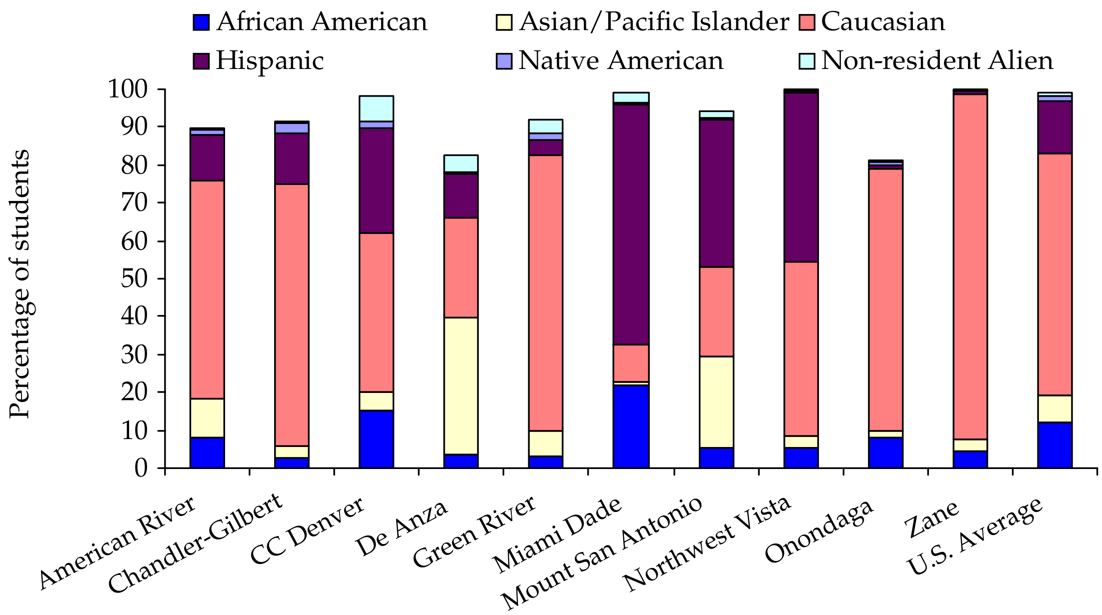
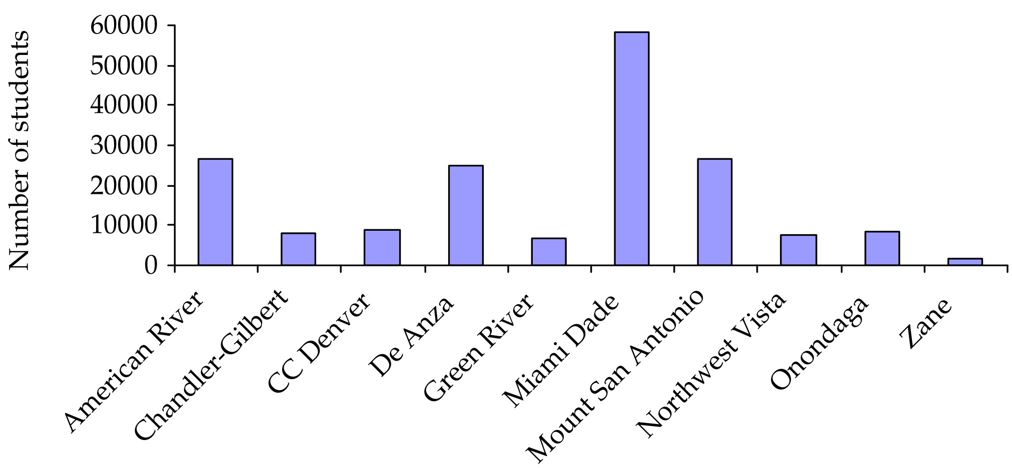


Figure 9: Total enrollment in selected colleges



Source: IPEDS 2005.

In terms of age, American River College and the Community College of Denver have the oldest student bodies, with 44 and 47 percent of the student body, respectively, under the age of 25 (table 8). In contrast, Northwest Vista's students are quite a bit younger, with 71 percent under the age of 25. The remaining colleges serve roughly the same proportion of students in this age range—about 55 to 65 percent.

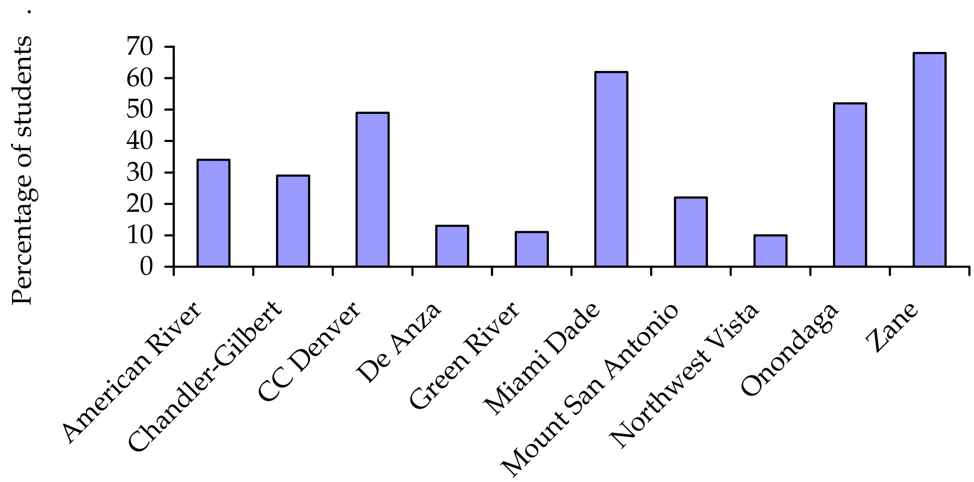
Table 8: Age of student body served in selected colleges

College	Age of students
American River College	44% under the age of 25
Chandler-Gilbert Community College	62.7% under the age of 25
Community College of Denver	47% under the age of 25
De Anza College	58% under the age of 25
Green River Community College	Median age is 23
Miami Dade College	60% under the age of 26
Mount San Antonio College	55.4% under the age of 25
Northwest Vista College	71% under the age of 25
Onondaga Community College	Median age is 21
Zane State College	63.4% under the age of 25

Source: Individual college Web sites, except for Zane College, the source of which is CCSSE 2004.

These colleges also represent students of varying socioeconomic conditions, as measured by the percentage of students receiving Federal grants—aid that is offered exclusively to students with the greatest demonstrated financial need (figure 10). Using this metric as a reference, Zane College and Miami Dade College serve the poorest students, with 68 percent and 62 percent of the student body, respectively, receiving Federal grants. In sharp contrast, just 10, 11, and 13 percent of students at Northwest Vista College, Green River College, and De Anza College, respectively, receive Federal grant money for their education. For reference, 17 percent of undergraduates attending public 2-year colleges received a Pell Grant in 1999-2000 (NCES National Postsecondary Student Aid Study 2005).

Figure 10: Students receiving Federal grants in selected colleges



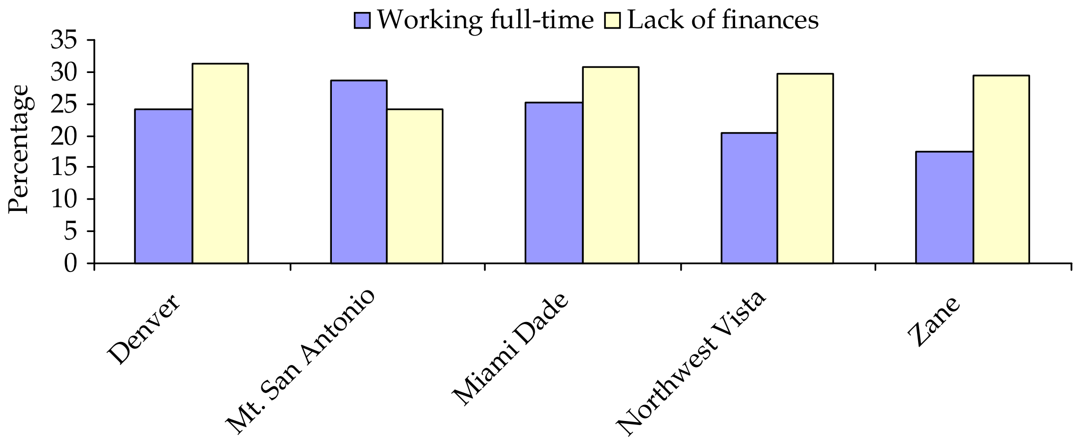
Source: IPEDS 2004.

It is interesting that financial aid needs do not necessarily correlate well with students' stated probability of dropping out of college due to financial pressures, as we illustrate with CCSSE survey data in figure 11 (CCSSE 2004).[21]

Only some of these colleges participated in the CCSSE, but they allow us to make an observation using two schools as an example. While the difference in the proportion of students receiving Federal grants at Northwest Vista College and Zane College is very large, there is virtually no difference in the percentage of students in these two colleges who feel that they are very likely to drop out of college either because of a lack of finances or because they are working full-time. Perhaps Federal grants, at least in these institutions, reduce the challenge that poorer students face in pursuing their college education, putting them more on a par with students who are better off financially.

[21] These results pertain to all students, regardless of developmental course status, number of credits, and so on.

Figure 11: CCSSE findings: Likely reasons to withdraw for selected colleges

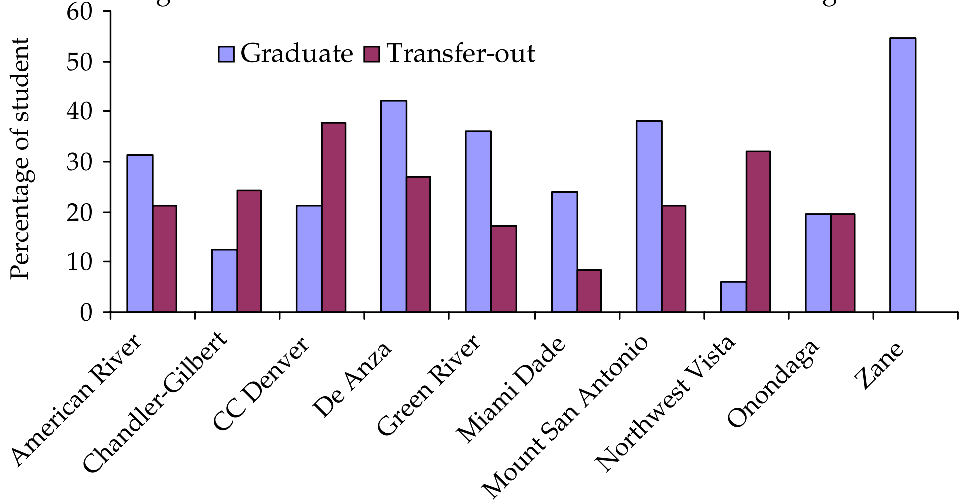


We turn now to differences across institutions in their graduation and transfer-out rates, both metrics we obtained from the Integrated Postsecondary Education Data System (IPEDS) (IPEDS 2005).[22] Note that the transfer-out rate was not available for Zane College. For reference, according to ACT, the average three-year graduation rate for public two-year colleges is 29 percent, while the average first- to second-year retention rate is 51.3 percent (Noel-Levitz 2005 (b)).

As we discussed earlier, the success of students through a developmental math program can be highly influenced by such factors as the intentions of the students concerning their academic plans when they first enroll in the college. Colleges with a high transfer-out rate would necessarily have a low success rate if they were not able to track students to the destination institution; this is the most common case. As we show in figure 12, Zane College experiences the highest graduation rate of all of the colleges, and Northwest Vista and Chandler-Gilbert the lowest. More than one in four students at the Community College of Denver, De Anza College, and Northwest Vista, however, transfer out of these institutions.

[22] Graduation rate is defined as the percentage graduating within 150 percent of the normal time to completion.

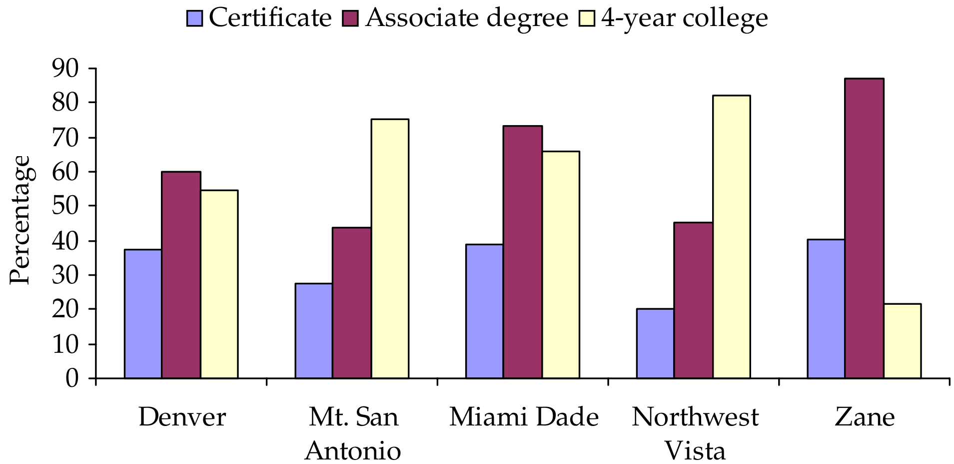
Figure 12: Graduation and transfer rates for selected colleges



Source: IPEDS 2005.

Again, we refer to the CCSSE for additional insight into some of these differences. Stark differences exist in the primary education goals of students taking the survey across these institutions (figure 13). Perhaps most striking is Zane College. Bearing in mind that they have a high graduation rate, we can see that far more students at Zane than at any other college have an associate degree as their primary goal, and the fewest of these Zane students plan to pursue a four-year degree. We will come back to this later, but we attribute this difference to the fact that Zane College is a technical college, unlike the remainder of our selected institutions. Its mandate is preparing students for the world of work vice transfer to four-year institutions. Its courses and degrees, therefore, would be far less attractive to students with aspirations of a four-year degree.

Figure 13: CCSSE findings: Educational goals for selected colleges



For reference, we summarize all of these basic characteristics of the student bodies served by our selected colleges in table 9. Across these various metrics, Chandler-Gilbert Community College and Green River Community College serve the most nationally representative student bodies; the remaining colleges serve a student body that differs fairly significantly in one or more of these metrics. Our selection of colleges, then, provides insights into strategies that are used by institutions that vary in the particular challenges faced by their students, allowing most institutions that offer developmental mathematics to adult learners to identify one or more colleges serving students with challenges similar to those faced by their own student body.

Summary of Program Characteristics

As part of our survey, we asked each college for information on a variety of issues concerning pedagogy, counseling, tutoring and lab availability, and so on. The responses to these questions are provided in appendix C.

Table 9: Student demographics in selected colleges relative to national average

College	Race/Ethnic	Age	Poverty rate	Size	Graduation rate	Transfer rate
American River College	Similar	Older	Average	Large	Average	Average
Chandler-Gilbert Community College	Similar	Average	Average	Medium	Moderately Low	Average
Community College of Denver	More African American, Hispanic	Older	Moderately High	Medium	Moderately Low	High
De Anza College	More Asian/Pacific Islander	Average	Low	Large	Moderately High	Average
Green River Community College	Similar	Average	Low	Medium	Moderately High	Moderately Low
Miami Dade College	More African American, Hispanic	Average	High	Very Large	Average	Low
Mount San Antonio College	More Asian/Pacific Islander, Hispanic	Average	Average	Large	Moderately High	Average
Northwest Vista College	More Hispanic	Younger	Low	Medium	Low	High
Onondaga Community College	More Caucasian	Slightly Younger	Moderately High	Medium	Moderately Low	Average
Zane State College	More Caucasian	Younger	High	Small	High	N/A

There is general consensus in our colleges in the following areas:

- Mandatory placement policies;
- Math requirement for associate degrees;
- Exit from developmental math is accomplished by receiving a "C" or greater in each course;
- Lecture is the predominant delivery method, with few requiring labs;
- Well-equipped computer labs with generous hours;
- Free tutoring services with both peer and professional tutors;
- Introductory and intermediate algebra do not confer college-level credit.

Referring to the results from our sampling of colleges from the Internet, we also find many similarities in a number of characteristics, especially the distribution of colleges offering three, four, and five credits for each course, type of credit, calculator policies, prevalence of labs, use and specific type of software, predominant delivery method, and textbooks used. Consequently, it appears that most introductory and intermediate algebra courses are covering much the same material and in the same general delivery format. This indicates, however, that these program parameters alone do not provide us with much insight into which strategies or approaches to individual courses tend to be most successful. In other words, it is not so much what is being taught, but how, and with what additional support systems, that differentiates our exemplary colleges. For an understanding of these strategies, we must look at more detailed information about each college.

Before we begin that discussion, we summarize below a number of the most basic components of the developmental mathematics courses, as well as a brief list of the most noteworthy components of the program in each college for ease of reference (table 10).

Table 10: Summary of basic program parameters and noteworthy practices in selected colleges

College	Placement Policy	Class Convening[2]	Delivery Method	Noteworthy Practices
American River College	Mandatory: Self-placement	90 hours per semester	Lecture, online and lecture, Online	Beacon peer study groups, study skills instruction, informed self-placement

College	Placement Policy	Class Convening[2]	Delivery Method	Noteworthy Practices
Chandler-Gilbert Community College	Mandatory: ASSET	3.5 hours per week	Lecture	Math Anxiety Reduction/Retention course incorporating overcoming math anxiety strategies, career exploration, study skills; strong advising.
Community College of Denver	Mandatory: ACCU-PLACER	5 hours per week	Lecture and lab, learning commun-ities with lab, lnline, branch campus	Strong advising, first generation student success program, uniform curriculum and exams, various pedagogical approaches, MyMathLab.
De Anza College	Mandatory: DTMS	5 hours per week	Lecture, computer aided, lecture with collabora -tive group work, and online	Math Performance Success Program: double the class convening time of regular class (10 hours per week); common activities, tests, and calendar
Green River Community College	Mandatory: Compass	5 hours per week	Lecture, online computer assisted, supple-mental independ ent study	Higher grade required to enroll in next course (B-), multi-step placement process, numerous pedagogical approaches offered.
Miami Dade College	Mandatory: ACCU-PLACER	6 hours per week	Combin-ed lecture, collab-orative study sessions,	6 hours of class convening, classes combine variety of pedagogical approaches, frequent assessment using numerous evaluative techniques.

College	Placement Policy	Class Convening[2]	Delivery Method	Noteworthy Practices
			lab	
Mt. San Antonio College	Mandatory: In-house for elementary algebra, MDTP 2 for inter-mediate algebra	4 hours per week	Lecture	Math Academy that combines elementary and intermediate algebra in a learning community; Math Activities Resource Center offering a variety of student support; strong commitment to faculty professional development.
Northwest Vista College	Mandatory: ACCU-PLACER	210 minutes per week	Instruct-or-led with collabor-ative learning, online	Advocacy Center providing strategies for students to remain enrolled in class; strong commitment to faculty professional development; uniform curriculum and calendars; Math Lab for Cooperative Learning providing additional tutoring, group work.
Onondaga Community College	Mandatory: Adapted MAA	200 minutes per week	Lecture, online	Review prior to placement testing; Math Diagnostic Program allows students to refresh math knowledge and place into higher courses; skill mastery requirements; after-semester workshop provides second chance for students to pass course in break after each semester.
Zane State College	Mandatory: ACCU-PLACER	220 minutes per week	Lecture, hybrid online	Noel-Levitz Retention Management Program to identify students at high risk of dropping out; strong advising; required orientation course; career exploration activities; skill mastery requirements.

[2]If different convenings are available for different levels of developmental mathematics or for

students in special programs within each course, we report the class convening time for the regular, elementary algebra course.

American River College[23]

American River College (ARC) in Sacramento, California, is part of Los Rios Community College District. In terms of race and ethnicity, the student population of 32,000, for the most part, resembles that of the United States as a whole. There are two major age groups of students at ARC: 18- to 20-year-olds (making up 22.3 percent of the student body) and those 40 years old and over (21.8 percent). This relatively large older cohort produces a student body that is slightly older than that of the average community college. In all other respects, American River College students are fairly typical.

We chose ARC because it has some of the strongest evidence of a successful strategy of any college we researched. In particular, its Beacon Program has enhanced the success of students regardless of age, race/ethnicity, and education credentials, with the most impressive improvements for those students who traditionally have had the highest rates of failure.

As background, ARC offers three instructional modes for introduction to algebra: (a) traditional, (b) a hybrid system that consists of two-thirds of the class time over the semester spent in online instruction and the remainder in traditional lecture, and (c) an open-entry and open-exit, independent study approach in which students may take as long as two semesters to complete the course, or complete it in less than one semester. Computer-based instruction is an important part of this latter option. Approaches (a) and (c) are offered for intermediate algebra; the hybrid option is not available.

Overall, ARC reports that the pass rate for introductory algebra is 49.3 percent and for intermediate algebra is 66.8 percent. As we will see, however, the pass rate in both of these courses is significantly higher for students who participate in Beacon.

The Beacon Program, inspired by the early work of Uri Treisman at the University of California, Berkeley, was created in 1992 in response to low achievement of minority groups in the fields of science and mathematics. The program consists of small study groups for individualized courses, which in the early phase included only math, chemistry, and biology but has since been expanded. Each study group is coordinated by a Student Learning Assistant, a student recruited by the instructor who successfully completed the course the previous semester and functions as an interface between the instructor and students

---

[23] Our points of contact are James Barr, Senior Research Analyst, Planning, Research and Development, and Azin Enshai, Professor of Mathematics.

participating in the study group. These student assistants receive specialized training in small group peer-assisted learning before the semester, and they are expected to meet weekly with the instructor. They also are paid for their work.

The study groups were originally scheduled to meet for three hours a week outside the classroom but currently are scheduled for two hours. In addition to covering course material, the Learning Assistant covers topics that help students learn the material and prepare for tests. For instance, these topics, summarized as "learning how to learn," include time management, effective reading for comprehension and test taking, note-taking skills, setting priorities, and other types of study skills.

Participation in Beacon is optional, and students are made aware of the availability of Beacon at the beginning of each semester.

ARC has conducted a fairly extensive study of the effectiveness of Beacon over the years, which has expanded to 89 different courses in 27 disciplines. In table 11, we provide details concerning the success rate of Beacon versus non-Beacon students by student characteristics. [24] The last column is the enhanced success rate of students participating in Beacon, where enhanced success is calculated as follows: the ratio of the success rate of Beacon students (column 2) to the success rate of non-Beacon students (column 3), minus one, expressed as a percentage. In other words, it is the additional percentage of Beacon students succeeding in their classes, relative to their non-Beacon peers.

A number of interesting results emerge from these statistics. First, in terms of its overall success, the pass rate for students participating in Beacon is 33 percent higher than for non-Beacon students. Some of the most impressive results, as we noted earlier, are for students in the highest risk categories. In particular, minorities who participate in Beacon, especially African Americans and Hispanics, are more likely to succeed in their courses than their peers who did not participate. Especially interesting for our purposes is the fact that students with a GED are (a) over 20 percent less likely to pass their courses than students with a high school diploma if they do not participate in Beacon and (b) 56 percent more likely to pass their courses than students with a GED if they do participate. Of course, these are simple statistics and do not control for the interaction of factors. Specifically, if students with GEDs are disproportionately members of a minority group, are poor,[25] are enrolled in elementary algebra, and so on, then some of these factors, and not simply the education credential alone, will have an effect on their success rate.

[24] The proportion of students succeeding in any class includes all grades in the denominator, including withdrawals. Thus, this is a measure of both persistence and passing grades within a class.

[25] While we do not include the statistics in the table, there is a positive correlation between reported income and success rates for non-Beacon students attending ARC.

The overall success of non-Beacon students is positively correlated with age; older students have higher success rates. This does not hold true for students who

Table 11: Enhanced success rate of Beacon versus non-Beacon students

Characteristic	Success rate of Beacon students	Success rate of non-Beacon students	Enhanced success (percentage)
Race/ethnicity			
African Americans	62.3	44.6	39.7
Asian	76.3	58.2	31.1
Hispanic	78.8	55.3	42.5
Caucasian	83.8	63.6	31.8
Age			
18-20	80.2	58.6	36.9
21-24	80.6	57.4	40.4
25-29	79.7	66.3	20.2
30-39	79.2	65.5	20.9
40+	79.5	68.1	16.7
First-time freshmen			
Recent high school graduate	75.8	54.1	40.1
Other freshmen	73.0	52.3	39.6
Academic credential			
High school diploma	80.5	60.7	32.6
GED	74.7	47.9	55.9
Level of course			
Basic Skills	75.8	69.0	9.9
Elementary Algebra	70.8	42.7	65.8
Intermediate Algebra	72.5	53.8	34.8
College-level, non-transfer	69.1	49.5	39.6
College-level, transfer	80.6	60.6	33.0
Overall	80.1	60.3	32.8

Source: Barr 2005.

participate in Beacon; all age groups benefit, but younger students do so

disproportionately. In essence, Beacon helps to level the success rate of students across all age groups.

ARC has also calculated the enhanced success of students by the level of the course, as well as for developmental math specifically. Students taking a basic skills course appear, in general, to benefit the least from Beacon, compared with all other student characteristics. However, students in elementary algebra who participate in Beacon have the largest enhanced success. These students have a 66-percent greater probability of passing the course than students who do not participate. The results for intermediate algebra, while smaller in magnitude, are still significant. These are impressive results, especially when we consider that no difference exists in the average assessment scores of students in English or Math between students participating in Beacon and those who did not. In other words, the "better" students did not necessarily self-select into Beacon. However, as we discuss later, ARC does not believe that these placement tests adequately assess student skill levels, so this type of self-selection bias may still influence these results to some extent.

Other self-selection issues may also contribute to these differences. For instance, those who voluntarily participate may be more determined and motivated to do well in math, or have a less demanding course load, thus allowing them both to participate and to do well in math. Also note that some instructors at ARC offer extra credit simply for participating in the Beacon Program, a policy that could artificially inflate the "success rate" of the program.

But what is it precisely about the Beacon Program that enhances student success? This is a difficult question to address and, as we will see, one that comes up repeatedly in our discussions of strategies at other colleges. ARC has conducted focus groups to better understand how Beacon benefits students, which suggests some of the mechanisms by which Beacon may help students.

For the most part, Beacon participants stated that the study group experience was enjoyable. ARC found it fairly surprising that a large number of students participating in Beacon had never been exposed to the concepts introduced in the program, such as study skills and time management, nor were they aware of the synergies produced from participating in a study group. ARC speculates that perhaps these students do so much better, not only in their Beacon classes but in subsequent courses, because their Beacon experience has taught them the important notion of "how to learn."

Students report that the informal interchange among peers regarding course material made learning more pleasant, and they found it was relatively easy to ask peer Learning Assistants questions related to course work—something they were not comfortable doing with instructors. Over time, students leveraged this newly found

skill with their instructors both in and outside Beacon courses, which they noted helped them to feel more connected with their instructors and their courses.

Students also identified study group discussions of learning strategies, test preparation, and time management as an integral component of their academic success. Overall, the study group format provided an environment conducive to learning and equipped students with the right tools to understand course materials in the classroom.

Their participation also had benefits that extended outside the classroom. These students reported that the study groups provided them with emotional support and other academic stimulation that was beneficial, especially since the college serves a large commuter population where regular contact with students is often lacking.

Finally, ARC found that significant benefits accrued to the Learning Assistants. In particular, they reported having a better understanding of the materials because of the need to explain it to the Beacon students. Some Learning Assistants reported that their Beacon experiences greatly enhanced their own study habits and success in subsequent courses.

We offer another possible explanation for the enhanced success of Beacon: it requires students to spend more time on task than they normally would spend.

Some of the components of the Beacon Program share common themes with strategies used in a number of our other selected colleges, as we will see. Some generalizations are possible, but absent scientifically based evidence, we are not able to suggest which effect(s) are the most important—time on task, social support system, study skills, increased confidence that allows students to be more engaged, and so forth. We will return to this point later.

A second noteworthy strategy employed by ARC concerns its assessment strategy. As we noted in our review of the literature, there is a growing consensus of the need for college-preparatory math classes to teach students the important skills of critical thinking, solving real-world problems, modeling, and so on. These are not easy skills to assess, especially with traditional course exams and assessment tests. ARC has been addressing this disconnect between what conventional assessment tests assess and what students need to know with a new self-assessment program.

Until 1999, ARC used the Math Diagnostic Testing Project (MDTP) to assess and place incoming students in math. Starting in 2000, ARC switched to the computer-based COMPASS assessment instrument. Over the years, however, some faculty members and academic counselors conducted research on the college's placement policies and found that assessment tools used at ARC had very little

predictive value of student success. As a consequence, a task force was formed to investigate the validity of past and then-present assessment tools at ARC. The ARC task force found that the MDTP and COMPASS assessment tests had equally poor predictive power. At that time, other community colleges were also looking into their assessment practices and were considering alternatives because of economic considerations. Hence, ARC was able to leverage some of the research other colleges had conducted regarding student assessment to reach its final decision.

Outside research did not identify any assessment tools that could accurately predict student success. Without alternative proven assessment tools and faced with a decreasing budget, cost weighed heavily in the final decision. The conclusion of the task force was to implement the Informed Self-Placement (ISP) model during the 2003-2004 academic year.

The task force conceived the ISP model as part of an organic approach in the student placement process. The ARC math faculty developed concise grading rubrics and course standards for math courses to ensure equal outputs for equal inputs. When deciding what course to take, incoming students have access to sample problems with which to measure their current math skills, clear course standards of what will be expected in each course available, and questions regarding personal characteristics to gauge overall college readiness. The "results" of this comprehensive self-assessment do not determine what math courses students will take. Instead, it provides vital information for students to share in discussions with academic counselors regarding their course options. Students are the final arbiters of their placement decisions.

Properly implemented, the ISP has several advantages over its alternatives, both for students and the college as a whole. In contrast to other assessments, the ISP engages the incoming student to a greater degree and, thus, gives the student a greater sense of "control" over his or her academic career. This sense of ownership can enhance academic persistence since students strive after self-defined goals. For their part, the math faculty members report that they find it is more enjoyable to teach students who feel more comfortable with their chosen courses in math. And the definition of course standards equips the math faculty with better understanding of the content of their own math courses. At the same time, the development of standardized grading rubrics builds cohesion within the department because the process requires open communication and compromise among faculty. In comparison with the COMPASS assessment, the ISP method represents considerable savings in resources for the college.

On March 1, 2004, ARC went live with an online student-driven self-placement process for math. Within a year, more than 8,000 assessments were completed. Since it is so new, ARC does not have hard data to evaluate the new process. However, the

college reports that a sample of students randomly selected during the online application process found the math assessment to be very helpful.

Chandler Gilbert Community College[26]

Chandler-Gilbert Community College (CGCC) is part of the Maricopa Community College District and serves more than 10,000 students in Arizona's East Valley. On average, the CGCC demographics resemble those of students nationwide.

CGCC first came to our attention because the League for Innovation in the Community College awarded CGCC the 2004-2005 Innovation of the Year award for its Math Anxiety Reduction/Retention Student Success (MARS) program. This program is especially noteworthy because of its innovative and successful strategies, with fairly strong evidence of success. It incorporates many of the strategies recommended by leading organizations reviewed previously, as well as those of other successful programs selected for this study, but also incorporates other constructive strategies.

Math Anxiety Reduction/Retention Student Success

CGCC offers students two options in introductory algebra: a three-credit course and a four-credit "Introductory Algebra with Math Anxiety Reduction/Retention" course. According to CGCC, the latter is an option that has been on the books for many years; however, because faculty did not have expertise in anxiety reduction, the additional class convening time (each credit represents the number of hours the course convenes each week) was devoted to covering more material, or covering the same material in slightly more depth, with little or no effort to address math anxiety.

Several years ago, faculty at CGCC decided that they wanted to address math anxiety specifically in that course. They did so because they knew that creating a safe, supportive, non-threatening, relaxed classroom environment is essential for helping developmental mathematics students overcome math anxiety and achieve success in mathematics. The faculty's review of research indicated that a number of common factors initiate, reinforce, or increase a person's degree of math anxiety, and that these common factors are directly related to the behavior and teaching methodologies of math instructors, such as making derogatory comments to students in front of their peers, exhibiting anger when students request help, verbally attacking and demeaning students who continually ask for help, embarrassing students by pointing out their mistakes to the class, sending students to the board when they make mistakes, and exhibiting a bias to gender or age. Instead, instructors need to create a supportive, relaxed, non-threatening environment where students do not fear making a mistake, where all questions are welcomed, and there is a true

[26] Our point of contact is Wayne Gautreau, Math Department.

classroom atmosphere that makes it clear that the course is a collaborative effort between the students and instructor dedicated to student success. This is the philosophy that guides instruction in all MARS classrooms.

The specific goals of MARS are to help students overcome math and test anxiety, improve performance, and increase success and retention. The instructional objectives include the following:

- Help students understand that math anxiety is learned;
- Teach students techniques to overcome the debilitating effects of math anxiety;
- Help students develop and implement appropriate study skills based on their learning styles;
- Teach students effective test-taking strategies;
- Help students establish academic and career goals;
- Help students assess their attitude toward math and their level of anxiety;
- Help students recognize personal traits they need to improve.

The MARS curriculum is part of the a four-credit, four-day-per-week introductory algebra course that has been designed and developed as a joint endeavor by CGCC's counseling and mathematics faculty. In addition to regular classroom lectures, the MARS program consists of five classroom presentations made by a counselor, with each presentation focusing on a different topic, including ways to overcome math anxiety, develop proven study habits, establish academic and career goals, and develop and employ successful test-taking techniques.

Before the first counselor presentation, students are instructed to fill out a Math Myths and Realities worksheet and the first part of a Student Attitude/Math Anxiety Study Habits (SMASH) survey. The Math Myths and Reality worksheet contains fifteen misconceptions related to mathematics; requiring students to fill it out demonstrates that there are a number of common but erroneous ideas about mathematics that help to justify the fear and frustration of students who suffer from math anxiety. The SMASH survey serves another purpose; it assesses a student's attitude towards math, his or her level of anxiety, and study habits in math. The survey is then used to identify areas that a student needs to improve in order to succeed in math.

The first MARS presentation sets the overall tone and framework of the program by first asking students to consider the negative effects of math anxiety on career goals. The counselor accomplishes this through four predetermined activities to assess personal attitudes about math, to emphasize the importance of math in acquiring a bachelor's degree, to understand the advantage of setting goals and committing to them, and to introduce the Career Exploration Research Project (CERP).

The CERP is an important component of the MARS program because a lack of well-defined education or career goals can undermine academic persistence. Helping students define and establish long-term goals for their academic and professional careers often strengthens academic success, which, in turn, bolsters persistence. We will see that addressing these goals also underlies strategies in some of our other selected colleges.

CERP requires students to take three Web-based career assessment inventories (personality, interest, and values), the results of which are later discussed with a counselor. After the discussion, the counselor gives the student a "Next Step" form with suggestions on how to clarify his or her education goals and how to cope with math anxiety. The student also receives a "CERP Completion Form" to give his or her instructor on completion of the project to verify that the student has completed the project as specified. Because of the importance of establishing clear education and career goals, all introductory algebra instructors are instructed to include the grade on the Career Exploration Research Project in computing the final semester course grade.

CGCC has found this part of the MARS program to resonate well with students. Feedback on surveys administered the past three years indicates that the vast majority—over 80 percent—responds that CERP helped to identify or clarify career goals, it helped to enhance educational motivation and commitment, and that it was, in general, a worthwhile exercise. This was true regardless of whether the student had indicated the he or she had already chosen a career before completing the CERP activities, suggesting that even students who are fairly certain of their career goals can benefit by greater career exploration and guidance.

Other counselor presentations include ways to identify math anxiety sources, symptoms of math anxiety, methods for overcoming math anxiety, study skill strategies, understanding students' individual learning styles, test preparation and test-taking strategies, and physical and mental relaxation techniques. Based on student feedback in the past three years, the most valuable material covered in the MARS courses is information on the knowledge of memory and how we interpret, store, and retrieve information; almost all students reported that to be very or somewhat important. Second to this is information on test preparation and test strategies; 94 percent of students found this to be important. In fact, all five presentations have met with overwhelming student approval. In no case did less than 80 percent of students feel that the material covered was not at least somewhat important.

The results of the MARS program are impressive and allow us to somewhat control for the effects of increased class convening time, as well as other factors. In

particular, both options for introductory algebra use the same placement criteria, cover the same course competencies, and use a common comprehensive final exam.

In spring 1999, before the incorporation of the MARS curriculum into the four-credit-hour class, about 10 percent more students passed (received a "C" or better) the three-hour course than the four-hour course (57 percent versus 52 percent, respectively). The first presentations of MARS took place in some sections of the four-credit course in 2000. In the spring 2000 semester, the relationship reversed; the overall pass rate of students in the four-hour course exceeded that of students in the three-hour course by 10 percent (63 percent versus 57 percent, respectively). Since then, the success rate of MARS students has increased steadily, while that of students in the three-hour course has remained relatively flat, resulting in a pass rate that is over 50 percent higher for students in the MARS introductory algebra section than students in the traditional three-credit section.

MARS students also do well beyond the introductory algebra level. Unlike most community colleges, CGCC is able to track students if they leave CGCC for any of ten sister-colleges in the Maricopa Community College District. This ability to track students within the district accounts for some of the difference in success, as we have defined it for this project, of CGCC students, but certainly not all. In particular, CGCC reports that about 68 percent of students who take MARS will successfully complete college algebra, a course that is required of all degree-seeking students at CGCC except for those in nursing or elementary education. In comparison, roughly half of students who take the regular introductory algebra course will pass college algebra.

As with all of our colleges, identifying which specific components of MARS are responsible for the increased success rate of students is not possible. What we *do* know is that, in the case of CGCC students, coordinated efforts to directly address math anxiety and a variety of study skills, in concert with career exploration and a focus on supportive faculty approaches to learning, have led to an appreciable increase in student success.

Community College of Denver[27]

Compared with the other colleges in our study, as well as in the nation, the Community College of Denver (CCD) serves a large minority population—especially African American and Hispanic—that is relatively older, poorer, and disproportionately not native English speaking.[28] It also has a daunting

[27] Our point of contact for the Community College of Denver is Darlene M. Nold, Director, Assessment & Research Center.

[28] According to the CCSSE, almost 27 percent report that English is not their first language,

developmental education mandate: it delivers one-third of all the developmental education offered at the postsecondary level in Colorado, and one-third of all the credit hours offered at CCD are for developmental education (Cutright and Swing 2005).

CCD also serves a population composed largely of students who are the first in their family to attend a postsecondary institution; two of every three students are in this category. Statistics concerning this makeup of college students are typically neither readily available nor reported by colleges. But the fact that CCD does so is an indication of the commitment it has to ensuring that these students succeed. Of all the colleges in our survey, and indeed of those we contacted or researched, CCD is unique in the extent of its programs targeted at students who face the greatest academic, financial, and personal challenges. In particular, it has an extensive network of programs for students who are first-generation college students, have disabilities, or are considered low-income. CCD has been acknowledged by a number of leading organizations for these innovative programs and its commitment to, and evidence of, student success. Two of these awards include the Policy Center on the First Year of College 2002 Institutions of Excellence Award and the 2002-2003 MetLife Foundation Best-Practices College in student retention. CCD is also a League for Innovation Vanguard college, one of twelve community colleges selected for pioneering work in learning-centered education.

It is impossible to discern the impact of these programs on the success of students in developmental mathematics in particular, but they certainly have an impact on student retention, which is a significant reason why many students do not successfully progress through a developmental math sequence. By 1995, students who first enrolled in developmental studies at CCD were as likely to graduate as those who did not require developmental courses. By 1998, developmental studies status was positively correlated with success. By the late 1990s, there was no difference in the persistence, graduation, or transfer rate of students based on race, ethnicity, age, or gender (Cutright and Swing 2005). These factors in combination explain why we selected CCD for our study.

CCD attributes its success to innovative educational practices (and the philosophy that one size does not necessarily fit all), close cooperation with two four-year institutions colocated on the main campus, institutional leadership, success in acquiring external funds to support campus initiatives, a commitment to accountability and continuous improvement, and an intentional focus on student success (Cutright and Swing 2005).

---

compared with 12 percent of all students taking the survey. For reference, the CCSSE was administered to CCD students in 2003.

Overview

Similar to all of the colleges in our study, and indeed to most colleges in the nation, CCD requires all incoming students to take placement exams, specifically ACCUPLACER, though ACT or SAT scores are also accepted. CCD had this policy in place long before the State of Colorado mandated placement tests of all incoming students at state colleges in 2001. And as we noted above, CCD serves a large number of developmental students. According to the CCSSE, almost half of incoming CCD students have taken, or plan to take, developmental mathematics courses.

All students have access to basic advising services, which include orientation, advice on financial aid, administering the placement exam, developing an education plan, and registering for courses. And, according to the CCSSE, roughly 40 percent of students enroll in a study skills course or an orientation program or course (CCSSE 2004).

Campus-wide advising strategies also include "Project Success Day," one day each semester in which all classes are canceled so that students can check their progress with their instructors. Recently, CCD implemented an online system, called Learning Early Alert Retention Network (LEARN), designed to help retain students and improve their academic performance. Under this system, if faculty members feel that a student has unsatisfactory academic progress or attendance, or that the student would benefit from tutoring, an electronic referral can be sent to the Academic Support Center, which administers tutoring and other student support. An advisor then follows up with the student.

Most noteworthy, however, is the academic advising that is targeted toward first-generation students, low-income students, and students with disabilities. Specific programs for these populations include First Generation Student Success (FGSS), Federal TRiO, and Title V programs. The FGSS is a program for students who are the first in the family to attend college, and it uses a unique Educational Case Management system, peer mentoring, learning communities, computerized instruction, and a focus on skills development.

In the Educational Case Management system, professional case managers work individually with students on academic advising and planning, career exploration and advising, financial aid advising, time management, connecting to tutoring and other academic services, crisis intervention and referral to other community-based services when needed. The case managers monitor the student progress and establish contact on a regular basis. Their efforts have impressive results; about 80 percent of students who complete their first year in the FGSS return the second year. This compares favorably with an overall first-to-second-year retention rate of about 50 percent of degree-seeking students (Cutright and Swing 2005).

The Federal TRiO program is intended for low-income students, first-generation students, and students with disabilities. In addition to the services provided to those in the FGSS, the TRiO program provides transfer assistance.

The FGSS and TRiO programs require a fairly high level of commitment on the part of students involved. In particular, students agree to meet with the advisor at specified milestones (for registration, review of academic progress, selection of a major), participate in at least one learning community, and attend a financial aid workshop and a career exploration workshop or activity. Further, if the student receives any grade lower than a "C," he or she must follow an academic intervention plan that could include such things as more tutoring or counseling from the Educational Case Manager. This is not just a tacit agreement; students must sign a document agreeing to these requirements, and they must waive privacy rights to certain records so that advisors have more complete records of students' financial, personal, and academic circumstances. In spite of these requirements, these programs serve a large number of students. For instance, about 600 students are enrolled in FGSS (Cutright and Swing 2005).

CCD also has a Title V program, begun in 2000 and funded by a five-year grant, that is designed to improve the retention and success of degree-seeking students with a declared major who are also low-income, first-generation, and minority students. Similar to those in the other targeted retention programs, students in this program are assigned an Educational Case Manager; however, because they are targeted toward a specific major, the managers are located in one of four academic centers: (a) Center for Arts and Sciences, (b) Center for Business and Technology, (c) Center for Educational Advancement, and (d) Center for Health Sciences.

Noteworthy Practices

First, as background, we note that CCD is required to provide remedial education to two four-year institutions that share the main campus (Auraria): Metropolitan State College of Denver and the University of Colorado at Denver, both of which represent a significant number of students. For instance, 47 percent of the 227 students enrolled in introductory algebra in the fall of 2002 were not CCD students. Thus, many of the students that begin developmental mathematics at CCD have no intention of pursuing an associate degree at the institution. It is uncertain what, if any, influence this arrangement has on the level and degree of commitment of non-CCD versus CCD students, and how the dynamics of the two types of students affect each other's performance in developmental math courses. Such proximity to, and sharing of, infrastructure and resources of two four-year colleges may help to motivate developmental students. Specifically, CCD asks students who transfer to either of these four-year institutions to return and act as mentors and

formal advisors to students that CCD believes could benefit from transfer aspirations. Conversely, as we noted earlier, students with lower academic aspirations tend to have higher completion rates, implying that CCD students would tend to have a higher success rate than the non-CCD students in the same class.

Even though we cannot discern the precise effect this unusual arrangement has on the success of CCD developmental math students, the success rate of CCD students in developmental math is fairly high. In particular, 62 percent of students who are placed into introductory algebra, and 55 percent placed into intermediate algebra, receive a "C" or better. Further, 70 percent of students in college algebra who were originally placed into introductory algebra receive a "C" or better.

Developmental math courses, up to but not including survey of algebra (an intermediate algebra course), are under the direction of the Center for Educational Advancement, which provides all of CCD's developmental courses. Survey of algebra is not technically considered a developmental course and does not confer transfer-level course credits. However, this course, like all higher-level math courses, is offered through the Math Department. CCD notes that the communication between the departments is very good; in fact, many faculty members teach math courses in both departments.

Consonant with the recommendations we found in the literature, CCD offers students a variety of instructional modes for introductory algebra. At CCD, this comes in the form of choices of instructional mode for the entire course, versus various approaches used within the same course. Without providing detailed analysis, however, the college reports no difference in the success rate of students by delivery method. The four modes offered are:

1. *Traditional lecture.* This is the predominant method of instruction. Students meet a total of four hours each week, plus they are required to attend the math lab one hour per week. This results in students required to spend at least five hours each week on the course, in addition to time outside class.
2. *Learning communities.* Four sections are offered, each with four hours of traditional lecture, plus a one-hour learning community enrichment requirement, the latter being taught by a different faculty member from the one teaching the math component.
3. *Online.* Two sections are offered online, using MyMathLab, and students take proctored exams in the CCD testing center.
4. *Branch campuses.* These courses are offered as open entry, with individualized instruction and very small classes that are, in some cases, self-paced.

Regardless of the delivery method, all classes use MyMathLab, which is bundled with the text, to some degree or another. The most extensive use is in the

online sections, in which students use the software for most of their homework and for online tests. For the other sections, MyMathLab is used as a supplement to instruction. They also rely on NetTutor for additional online student support. Also, CCD offers online tutoring four nights a week, for two hours each night.

The Center for Educational Advancement requires uniform mid-term and final exams, a consistency that it feels benefits the students. However, the center also allows faculty members latitude in the delivery of the instruction within each class and notes that instructors emphasize an active learning environment. Teachers make frequent use of real-world problems and allow a significant amount of time within each class for students to practice their skills, either in guided practice or by using cooperative learning.

Since Survey of Math, an intermediate algebra course, is offered outside developmental mathematics, its approach is somewhat different. Similar to introductory algebra, this course is also offered either as a traditional lecture with a one-hour lab, as a learning community, or online. It also offers a ten-week accelerated online version. However, grading and exams are more at the discretion of the faculty member. Further, MathXL, rather than MyMathLab, is used in the learning community sections, and is optional for other sections. Most faculty members do not use it, however.

When asked what it believes are the most successful strategies employed in teaching developmental math, CCD mentioned a number of factors, including (1) mandatory placement, (2) a transition of classes into a more active learning environment, (3) increased time on task as a consequence of the lab requirement, (4) giving students plenty of opportunity to practice the skills they are being taught, (5) the special programs for students that we described earlier, (6) a very organized department, with departmental tests and consistent curriculum, which at the same time allows for teachers to use their own individual style, (7) an increased use of technology in the classroom with the use of MyMathLab and NetTutor, (8) development of a set of customized textbooks, which allow the addition of original material into the textbooks, and (9) continuous efforts to improve and seek out more effective strategies for a continually changing and diversified group of students.

We would concur that all of these factors contribute to the success of developmental math students at CCD. Indeed, many are consistent with the strategies used by most of the exemplary programs included in our study. Absent scientific studies, it is difficult to determine the impact of each component. Based on our research, however, we feel that the targeted support programs at CCD for the most high-risk students are unusual in their scope and breadth of services offered, and perhaps are especially helpful in retaining students at CCD in these populations, which in turn represent a significant proportion of the entire student body.

De Anza Community College[29]

De Anza College (De Anza) in Cupertino, California, serves a fairly large student body that is disproportionately composed of Asian and Pacific Islanders. It is relatively well off financially compared with the other colleges in our study, as well as with the nation. Students at De Anza also graduate at a rate that is significantly higher than the national average.

We selected De Anza College because of a program it has created for developmental math students who have had previous difficulty in math, such as failing a course, having difficulty with math in high school, or suffering math anxiety. The program is called the Math Performance Success Program (MPS). Students who volunteer to participate must be willing to commit to twice the normal class time of regular developmental math classes, but the rewards are impressive. About nine of every 10 students in MPS will pass the course—a rate that is as much as 80 percent higher than for students in similar courses that are not in the MPS program.

While the program is intended for those with previous difficulties, many of the components of MPS are consistent with the recommendations of AMATYC and others, and share similarities with many of our other exemplary programs.

Before turning to a description of the MPS program, we provide some insight into the challenges and behavior of developmental math students at De Anza College that may be indicative of larger scale phenomena. In particular, in 2002 De Anza administered a survey randomly to 165 students in elementary algebra and 140 students in intermediate algebra that covered a variety of topics related to personal demographics, education goals, study habits, previous experiences in math and science courses, and feedback on a number of pedagogical approaches. Responses to several of these questions are relevant to our purposes, although we acknowledge the fact that these findings are based on self-reported phenomena and on student impressions, which may or may not correlate well with actual outcomes.

First, in terms of behavioral issues regarding the courses themselves, it appears that relatively few students in either course make use of student services, but students in the higher-level algebra course utilize them to a somewhat greater extent. In particular, 31 percent of students in intermediate algebra report that they use tutorial services compared with 22 percent of elementary algebra students. However, slightly more elementary algebra students attend instructor's office hours at least some time during the semester (50 percent versus 44 percent), but neither group makes extensive use of this resource either; less than eight percent of students in each

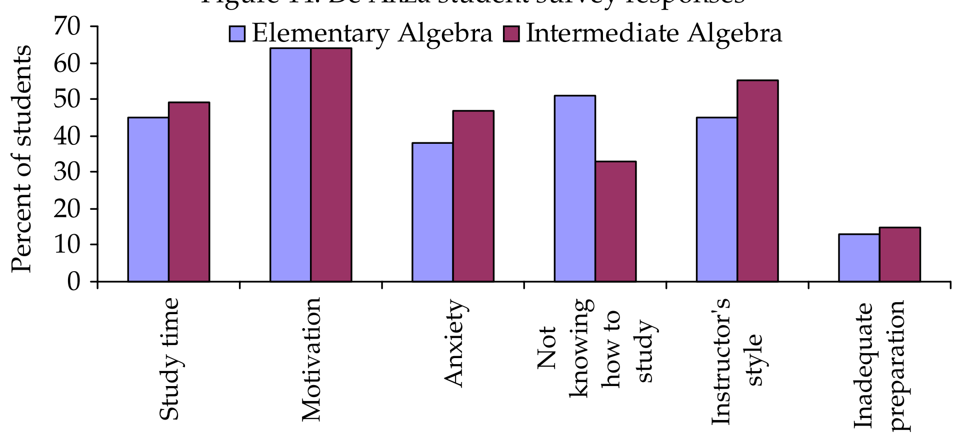
29 Our points of contact are Diane Mathios, Math Instructor and Andrew LaManque, Supervisor, College Research.

class report that they see the instructor more than four times per quarter.

Further, a large number of students in both classes spend less than four hours per week on homework or studying for each four- to six-unit math, science, or engineering class (52 percent of the elementary algebra students and 46 percent of the intermediate algebra students). In combination, the responses to these three questions provide us with a good indication that relatively few students in either of these courses are spending much "time on task" outside of the normal class time, whether in tutoring, seeing the instructor, or in doing homework, studying, or other activities.

The survey also asked students to indicate whether they had ever received a "D" or "F" in a math, science, or engineering class (roughly one in three students in each class responded "yes"), and, if so, what factors contributed to that lack of success? The top factors for students in elementary algebra varied slightly from those in intermediate algebra, but there is general agreement. We display in figure 14 the top reasons for each class, as well as those responding that not being academically prepared for the level of the course was a contributing factor.

Figure 14: De Anza student survey responses



Regardless of the level of the course, these five factors (excluding inadequate preparation) all rank in the top of the eleven reasons provided (over 40 percent of each reported that other reasons also contributed to their failure). Note that for both classes, by far the most common reason for failure was lack of motivation or interest; 64 percent of students who failed a course previously in both classes indicate that this was a primary reason. In sharp contrast, only about 15 percent of students in either class said that they failed because they were not academically prepared.

Other significant factors included the lack of study time (which may explain

why students are not spending much time on task), math or science anxiety, not knowing how to study, and a dislike for the instructor's teaching style.

In contrast, the survey asked all students to indicate which of a number of practices were useful to their learning experience. Of those pedagogical strategies that were used by the instructor, over 60 percent of students in each class reported that a class Web page or listserv, computer lab, group study sessions, linked class with another class, group projects, and in-class group work were all useful. Students in elementary algebra found the computer lab and group study sessions the most useful (89 and 87 percent, respectively), while students in intermediate algebra found in-class group work and computer labs to be the most useful (76 and 73 percent, respectively).

The Math Performance Success Program

MPS is a collaborative approach to supporting students with a record of difficulty in math. MPS instructors, counselors, tutors and mentors work together to help at-risk students succeed at a sequence of courses through additional instructional time, supplemental tutoring, and academic counseling.[30] An important component of the developmental program, evident throughout MPS, is a team orientation. Other key elements of the program include the placement policy, pedagogical methods, and counseling systems.

The placement strategy for MPS ensures that students who need the additional mathematical course work receive it. A placement test (the Descriptive Tests of Mathematical Skills (DTMS)) helps to identify which students might benefit by MPS. Students in programs offered by the Student Success and Retention Services Center (SS&RSC)—designed to support students with historically low retention and transfer rates, first-generation college students, and reentry students—are also recruited for MPS.

MPS is a three-quarter math sequence program consisting of elementary algebra, intermediate algebra, and a college-level transferable course, elementary statistics and probability. Two sections of each of these courses are offered each year to reduce the number of students in each class; each class typically has twenty-five to thirty students, with a classroom ceiling of forty students.

As we noted earlier, a significant component of MPS classes is the increased time required for class convenings, which is double that required of students in similar courses that are not MPS. In particular, non-MPS students enrolled in these same classes meet each week for (a) five hours in lecture, (b) four hours in lecture

[30] Students pay for just 5 units while attending 10 hours per week. Faculty are paid for a double class load and De Anza is reimbursed for this additional cost by the state of California.

and three hours in lab, or (c) four hours in lecture and two hours in a combined lab and lecture. MPS students attend ten hours of class each week, time that is divided equally between lecture and group work. Classes include both whole-class activities and collaborative group work. Instructors use discovery-oriented demonstrations and guided activities that lead students to the concept before teaching the rule. And instructors regularly use real-world problems in their lectures and assignments. This methodology aims to bring the value of mathematics education to life for students. Finally, the course work emphasizes functions throughout the courses, making it a unifying concept among the three courses.

MPS relies heavily on significant collaboration between instructors, students, academic counselors, and tutors. The whole program works together to support students and increase their chances of success throughout the sequence of math classes. For instance, MPS instructors collaborate on common activities, a common calendar, and common tests, which allow students from different sections to work and learn together. Mentors and tutors are available daily during class to help students during class time, especially during the group work portion of the class. In addition, academic counselors are available for one hour a day in the classroom to answer questions regarding grades, missed assignments, or absences. Counselors also are available to meet with students every day to discuss college planning, grading, attendance, and personal questions or concerns, and they are available by appointment to address an array of concerns, including math anxiety. Equally important, counselors work closely with the course instructors and discuss and communicate concerns about student achievement and class activities.

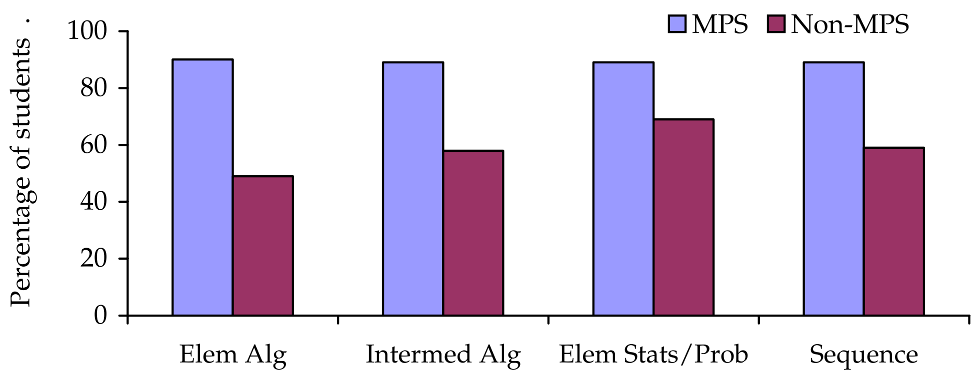
The team orientation does not stop at the classroom. Group tutoring occurs outside the classroom. Each week tutors who have been specially trained to reinforce the concepts taught in the class are available to MPS students for forty hours, both inside and outside the classroom.

Another key element of MPS is the study group, which includes group work outside the classroom and usually includes at least one tutor. MPS also arranges for informational sessions about college transfer credit, and for guest and inspirational speakers about technical careers involving mathematics.

There is strong evidence that the Math Performance Success Program works. Figure 15 illustrates the difference in the percentage of students receiving a "C" or better in the same classes by MPS status for the 2002-2003 academic year. The greatest benefit of MPS accrues to students in the lowest level of developmental math, elementary algebra. MPS students in that course are over 80 percent more likely to pass than non-MPS students, in spite of the fact that the MPS students have a documented history of difficulty in mathematics. The enhanced success rates of MPS students decrease with increasing levels of math; 53 percent more MPS than

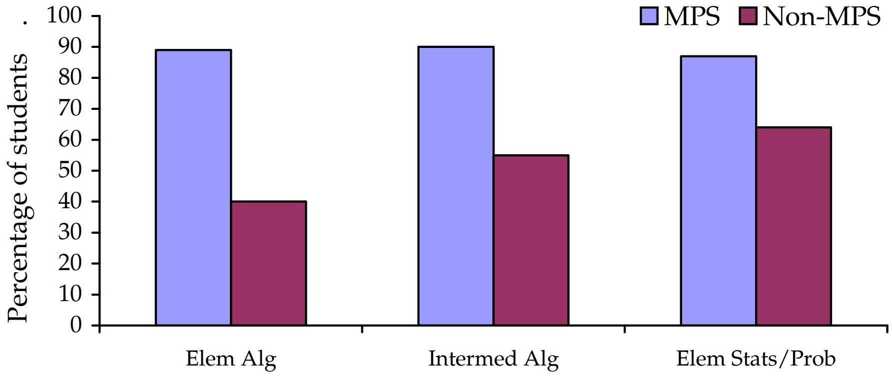
non-MPS students pass intermediate algebra, and 29 percent more pass elementary statistics and probability, but this is because more non-MPS students pass higher-level math courses—not because fewer MPS students do so. This phenomenon would imply that only non-MPS students who did very well in the lower-level developmental math courses continue in the sequence, which is supported by the last metric displayed in figure 15. Specifically, 50 percent more MPS than non-MPS students are able to successfully complete the entire three-course sequence.

Figure 15: Pass rate of all DeAnza students by MPS participation



MPS has also proved to be especially beneficial to high-risk minority students. In particular, the MPS sections of the three math courses have twice as many African Americans and Hispanic students as the non-MPS sections, and these students benefit far more from MPS; the differential in the pass rate for ethnically underrepresented students enrolled in MPS versus similar students in the same courses who are not in MPS is larger than it is for all students, as we illustrate in figure 16. Specifically, while the pass rate for ethnically underrepresented students enrolled in MPS is almost identical to the average pass rate for all MPS students, they are 122 percent, 64 percent, and 36 percent more likely to pass elementary algebra, intermediate algebra, and elementary statistics and probability, respectively, than ethnically underrepresented students who did not enroll in MPS.

Figure 16: Pass rate of ethnically underrepresented DeAnza students by MPS participation



Similar to other colleges in our survey, the data do not permit us to conclude which components of MPS are the most effective in enhancing the success of high-risk developmental math students. Is it the increased time on task, the group work, the support of tutors and counselors, the study skills and career exploration that accompany the program—or is it some combination of all of these? We will come back to this point later.

Green River Community College[31]

Green River Community College (GRCC) is in Auburn, Washington. Described as the "world's biggest small town," the city of Auburn has nearly 50,000 residents. The median household income for the county is above the national average, and is reflected in the fact that 35 percent fewer GRCC students receive Pell Grants than the nationwide average of two-year public college students.

There is no singular approach to developmental mathematics that we highlight as especially noteworthy. Rather, Green River's developmental mathematics is exemplary because it addresses the AMATYC *Crossroads* standards and principles and goes even further in meeting effective student learning through its multifaceted approach, incorporating strategies that extend beyond the math classroom itself. The results of these efforts are impressive. While 75 percent of students place into developmental mathematics, their success, as we have defined it, is exceptional; 38 percent of students who take introductory algebra successfully pass a college-level math course.

GRCC's developmental math program starts several steps before students begin their classroom learning. Placement into developmental math courses is often

[31] Our point of contact is Frank Wilson, Mathematics Instructor.

a three-tiered process beginning with the placement exam. Each student is required to take the COMPASS test, which is used as an initial screen. To ensure that students are properly placed, the Math department also developed entrance exams for each course. Entrance exams are given to students within the first three days of class with the notion that they will earn 80 percent or above. Depending on the score each student receives, advice is given by the instructor and students are encouraged to either remain in the class or shift into a more appropriate course level. GRCC recognizes the importance of a hands-on approach with each student, giving the Math Department authority to set these placement policies and adapt them as needed. And beginning in 2005, the Math department implemented Mathematics Advising Placement Sessions (MAPS) that are conducted by mathematics faculty to ensure proper placement of new students.

One of GRCC's most effective developmental mathematics strategies is how students transition through developmental math and then into college-level courses. Advancement to the next course depends on a minimum grade earned, similar to most colleges, but GRCC has set an especially high goal for students in elementary algebra; they must achieve an average GPA of 2.5 on a 4.0 scale (roughly equivalent to a B-) in introductory algebra to advance to intermediate algebra. Furthermore, this minimum grade must be earned to advance through all courses leading up to introductory algebra. Students must earn a GPA of 2.0 to advance from intermediate algebra (e.g., transitioning out of developmental mathematics) to a 100-level college mathematics course.

By requiring a relatively high grade in the prerequisite course, GRCC hopes to ensure that students have sufficient mathematical skills to succeed in the subsequent course. In fact, as we noted earlier, according to a study of students who took courses at GRCC in 2000-2001, 45 percent of the introductory algebra students reached a college level math course, and 38 percent of the original cohort of introductory algebra students passed their college-level math course with a grade of 2.0 or higher.

GRCC offers a variety of course formats from which students may choose: (a) lecture, (b) online computer assisted, and, (c) a supplemental independent study course known as the "math module". The online computer assisted sections use the Academic Systems software. Since the software is Web based, it is available to students in the lab, school and community libraries, classroom, and at home. Most students, however, still choose to enroll in the traditional lecture format.

Lecture sessions at GRCC convene in a variety of formats to fit student schedules and learning styles. Similar to other colleges in our survey, developmental math courses at GRCC convene for longer than the three- or four-hour times of traditional classes; the five-credit developmental mathematics courses convene as

often as five times a week and as little as twice a week. Green River is unique among our colleges, but consistent with the recommendations of AMATYC and others, in using a variety of software applications to present material inside the classroom, including Maple, PowerPoint, and Excel. In our research, we have found relatively few colleges that include spreadsheets in developmental math curricula.

Also consistent with these recommendations, graphing calculators are required for each course. GRCC's Mathematics Department does not mandate specific teaching techniques, but nearly all instructors incorporate the use of real-world problems, independent research, and interdisciplinary problems. Many instructors incorporate activities that require students to collect and measure their own data, interpret their results, and make presentations to classmates.

The GRCC Mathematics Department provided us with specific teaching techniques that are frequently used, including "Making It Real" research projects, students' board work of sample homework problems during lecture, and student homework presentations at the board. The pedagogical approaches that are often noted in informal student evaluations as being most effective are those in which students help each other learn. For instance, some instructors practice the technique of presenting a new concept or new material and then sending the entire class to the board to work individually on a problem. Once everyone is finished, students return to their seats and the instructor highlights the students' board work. The class discusses the strengths and weaknesses of the various approaches; both successful and incorrect techniques are discussed. The discussion allows students to help one another in problem solving, addressing concerns, and putting information in a new light.

Another approach has to do with reviewing and discussing homework assignments. First, students identify the problems they had the most trouble solving within the assignment. Student volunteers then work out the solutions for the class with the instructor providing supplementary detail as necessary. In this way, students are helping one another solve problems and learn techniques and content.

Study groups, which are widely used at GRCC, also incorporate the peer learning and teaching strategy. One professor with whom we spoke invites students who earn 90 percent or higher on the first exam to be study group leaders. These students commit to a one-hour study session each week on campus. All students attending these sessions earn three extra credit points per week out of a total 1,000 points possible for the entire course, and study leaders whose pre-final exam course average is 90 percent or higher may opt out of the final exam.

Recognizing that some students need extra time to learn material, GRCC has established a one- or two-credit independent study course known as the "math

module." Often taken concurrently with the main course (e.g., introductory or intermediate algebra), the module points students to the numerous mathematical resources in the Math Learning Center. Students spend twenty to forty hours working independently to master their areas of weakness. At the end of the quarter, students submit a binder of completed work. Essentially, math modules give students credit for putting in extra time to learn the material. Math modules, however, are not full versions of the course and therefore do not satisfy prerequisites for more advanced math courses.

Beyond the students enrolled in math modules, the Math Learning Center (MLC) at GRCC is widely used. A full-time director who is also a part-time mathematics instructor oversees the MLC, and it is staffed by student tutors. It also has the benefit of being located on the same floor as the mathematics faculty offices. The MLC is rich with resources, including math videos, computers, course and supplemental textbooks, practice exams, and calculator rental.

The MLC encourages students to "take charge of their learning," and suggests that students use it as a venue to meet in study groups. Developmental math students may also check out videos or supplemental math books to help them with their classes. Software is available on the MLC computers, including a basic college mathematics tutorial, a pre-algebra tutorial, and math trek. For students who are enrolled in an introductory or intermediate algebra lecture course, there is also a tutorial called iLrn that can be accessed.

The MLC also offers tutoring assistance at no cost to students, and it is available almost fifty hours each week. GRCC maintains high standards for students who wish to become peer tutors; they must maintain at least a 3.5 GPA in their math classes and be recommended by a faculty member. In their preparation to become tutors, students watch a video presentation on policies and procedures, receive a handout with guidelines, and sit down for one-on-one training with the MLC coordinator. Tutors are given a role-playing situation to see how they respond to questions and various situations. Afterwards, they are evaluated and given suggestions for dealing with students at different levels. Periodically throughout the quarter as they are being observed, tutors receive positive feedback on their work, as well as suggestions to help them become better tutors.

We summarize the key elements of GRCC's developmental mathematics program as follows:

- A multistep placement process that goes beyond standardized placement tests;
- A high GPA exit requirement for students transitioning to higher level math courses within the developmental math sequence;

- A longer class convening time;
- Numerous pedagogical approaches for students to choose from;
- Use of real-world problems, independent research, and other hands-on learning experiences;
- Use of collaborative work in the classroom, allowing students to see multiple approaches to problem solving and to communicating mathematics in a variety of formats;
- Fairly widespread use of study groups and peer learning;
- Opportunities for students to spend more time on task with supplemental study courses;
- Extensive resources in the Math Learning Center;
- Well-trained and well-monitored peer tutors.

***Miami Dade College*[32]**

Miami Dade College is by far the largest community college in our study, as well as in the nation. The college also serves the largest minority population, especially African Americans and Hispanics, relative both to our selected colleges and to the national average (see figure 8); less than 10 percent of Miami Dade College students are Caucasian, compared with a national average of 64 percent. In addition, Miami Dade graduated more minority students with associate degrees in 2002-2003 than any other college in the nation (Community College Week 2005).

Such a diverse population presents a particular set of challenges. According to the CCSSE, one of every two Miami Dade students reports that English is not his or her native language, a rate that is four times the average for all students participating in the survey. In addition, almost two out of three Miami Dade students receive federal grants for their education, second only to Zane State College among colleges in our sample. An almost equivalent number state that they have taken, or plan to take, a developmental math course. This is 34 percent more than the average of all students completing the survey (CCSSE 2004). In spite of these challenges, Miami Dade College students graduate at a rate that is only slightly lower than the national average (24 percent) (IPEDS 2005).

All community colleges in Florida are governed by state-mandated rules and regulations concerning major portions of their developmental math program. In particular, the state of Florida requires all entering freshmen in a degree program at any public community college or state university to take a common placement test in math, reading, and writing (Sherry 2003). Florida uses a computerized, adaptive test, called the Computerized Placement Tests (CPT), which was developed by the

[32] Our point of contact is Norma Agras, the Chair of Mathematics in the Wolfson Campus of Miami Dade College.

College Board and is part of the ACCUPLACER system. Students scoring a 72 or higher on the elementary algebra component may take intermediate algebra, or take a second placement test, the College Level Mathematics, for placement at or above intermediate algebra.

The state requires all students not meeting the minimum cutoff scores to enroll in college preparatory courses and prevents such students from enrolling in college-level courses in that subject until they have passed the Florida College Preparatory Exit Test. The state also stipulates that students may only take the same college preparatory course two times and pay the in-state tuition rate, after which they must pay the out-of-state tuition rate. In general, they are not allowed to take the same preparatory course a fourth time.

Finally, all colleges in Florida follow the same course naming and numbering system; college preparatory math courses are up to and include basic algebra. None of the preparatory courses confer college credit, and the next math course in the sequence, intermediate algebra, is considered a transitional course that confers elective credit only.

Even with these state-mandated requirements, variation exists in the pedagogy, textbooks, assessment policies, etc., that are used in individual community colleges in Florida. We selected Miami Dade because of its fairly high success rates in developmental math, particularly given the economic and language challenges faced by so many of its students. Seventy-two percent of students placed in college preparatory algebra in the fall of 2001 passed the course, and 24 percent of those originally placed into that course passed a college-level math course within three years. In addition, 78 percent placed into intermediate algebra in the fall of 2001 passed the course.

Miami Dade College has a strong commitment to learning-centered education; it is a Champion College in the League for Innovation in the Community College's Learning College Project (League for Innovation 2005). Nearly 40 percent of Miami Dade students responding to the CCSSE survey indicated that they have participated, or plan to participate, in an organized learning community, a rate that is 44 percent higher than all students responding to the survey.

All entering students at Miami Dade have the opportunity to enroll in an orientation course, and, according to the CCSSE, almost half of the students do so. Roughly half of the students indicate that they have taken, or plan to take, a study skills course (CCSSE 2004), a rate that is 50 percent higher than all students taking the survey. Perhaps this is why so many students at Miami Dade—almost 37 percent—say they are very satisfied with skill labs, a level of satisfaction that is 57 percent higher than all students participating in the CCSSE.

Similar to other large campuses, Miami Dade has less intervention and advising of incoming students than we will see in other colleges, such as Zane State. Even so, all students have access to the Florida online student advising system (www.facts.org), which, among other services, provides them with information concerning career objectives, offers help in choosing a major, and tracks their progress toward a degree. But, in general, academic advising is not especially noteworthy at Miami Dade; 26 percent of Miami Dade students said that they were very satisfied with academic advising, compared with 27 percent of all students participating in the CCSSE survey in 2004 (CCSSE 2004).

We chose the Wolfson Campus of Miami Dade College to collect more specific information concerning the developmental math program at Miami Dade. Wolfson is located in downtown Miami and serves 27,000 students. The math department at Wolfson teaches over 4,600 students each major term, many of them in courses that are below the college level. In addition, the chair of the Mathematics department at Wolfson, Norma Agras, is the director of the state of Florida's project titled "Developmental Mathematics: A Plan for Florida's Community Colleges". This project is a result of the concern that educators around the state had regarding the low pass rates in intermediate algebra and the first college-level math course of students who took intermediate algebra. The Plan is now in the early stages of implementation.

Two components of Miami Dade College's Wolfson Campus developmental mathematics program are particularly noteworthy. First, its approach to teaching uses a wide array of methods to address different student learning styles, a necessary component of courses that we noted in our literature review. This same varied approach to teaching results in the second noteworthy component; it allows frequent assessment of student progress, again addressing various different learning styles, as well as assessing a number of skills and abilities that are increasingly important, as described in the *Crossroads* document, the American Diploma Project, and others.

Wolfson's philosophy in college preparatory math is:

> Create a student-centered active learning environment that includes project-based learning, collaborative group work, and many problem-solving opportunities. Students should become more confident problem-solvers and gain some level of quantitative literacy. Further, students should be prepared to continue to college level courses and programs.

In our discussions, they also noted that their approach reflects the fact that experiences of students in developmental mathematics must be appropriate for adults; the curriculum must not be simply an acceleration of high school math.

Faculty members need to look at students' particular needs, in terms of curriculum, pedagogy, and assessment, and understand that a one-size-fits-all approach is not effective. Students at this level need to develop a quantitative literacy and not simply be prepared to take advanced math, a path that is not necessarily taken by all developmental math students.

This philosophy results in all College Preparatory Math courses (up to but not including intermediate algebra) requiring six to eight contact hours per week, which is significantly more than all but a very few colleges we surveyed in this research. In particular, college preparatory arithmetic and college preparatory algebra require six contact hours per week, and college preparatory mathematics requires eight contact hours per week.

In addition to more time on task, the increased convening time allows for multiple classroom approaches. One part of each course consists of three hours of instruction in a classroom setting. Because the emphasis is on the student-centered active learning environment that is the core of this philosophy, instructors are strongly urged to allocate time to group work as well as lecturing in this segment of the course.

The second component consists of a one-hour or two-hour scheduled study session (depending on the course), staffed by full-time professionals associated with the campus math lab. These sessions are held in rooms that are almost exclusively furnished with round tables to facilitate group work; students usually work in groups on homework or projects, and the facilitator walks around and coaches and assists. Sometimes quizzes are administered.

The third component is a one-hour or two-hour lab (again, depending on the course), in which students work on homework, receive tutoring, and so on. This is an unstructured hour, and students attend any time in the week that the lab is open. Their attendance is recorded.

Their next level math course, intermediate algebra, is developmental but not preparatory. This course has three options: the more traditional three-hour per week lecture format, a synchronous Computer Assisted Instruction (CAI), which is not self-paced, and a collaborative approach, which includes more group work as well as some lecture.

The second noteworthy component at the Wolfson Campus, as well as Miami Dade in general, is frequent assessment of students to ensure that they are making adequate progress in each component of the course. The approach used in the Wolfson Campus follows the guidelines put forth by AMATYC, The American Diploma Project, and others. Specifically, these frequent assessments are intended to

discern whether students are developing critical thinking skills, conceptual understanding, the ability to solve problems, and the ability to communicate mathematics in several forms—in writing, graphically, and orally.

Although often easier to construct and to grade, multiple-choice and true/false exams typically cannot adequately assess these skills and abilities, so their use is minimal. Instead, Wolfson requires that assessments be done using a variety of instruments, again to reinforce the types of skills and abilities that will be required of students in higher-level math and in the world of work, as well as to acknowledge the broad range of learning styles. Therefore, emphasis is put on collaborative work and in communicating mathematics using a variety of methods. These assessments take the following form:

- *Solving problems at the board*—allows the student to demonstrate such skills as problem solving and communicating math concepts;
- *Quizzes*—either individually or in groups;
- *Homework;*
- *Small group activities and presentations*—help to foster greater collaborative work and the skills necessary to communicate mathematics both orally and in writing;
- *Projects that require students to model problems and to share their results with peers*—such projects teach that there are multiple approaches to problems;
- *Exams*—at least four are administered each semester, with a minimum of multiple-choice questions in each.

Because the campus is so large and the Math Department must serve so many students, particularly in courses below the college level, a large percentage of the faculty members are adjuncts. This presents a difficulty that they readily acknowledge. In part to mitigate these problems, faculty members periodically attend retreats, AMATYC, MAA, and other professional meetings and development activities.

Faculty members also note that they have had a recent shift in the content and delivery of their college preparatory courses that includes empowering students to know the vocabulary of mathematics and use it effectively, to demonstrate quantitative literacy and number sense, to think analytically and solve problems, and to use technology effectively and appropriately. Multiple classroom techniques and the variety of assessment tools are evidence of this shift.

The last strategy that Wolfson notes is the adoption of a new textbook for beginning and intermediate algebra in the fall 2003. This textbook better reflects the Standards of AMATYC and its adoption has resulted in a higher proportion of students successfully progressing to higher-level math courses. As we note in table C-4 in appendix C, both courses are now using *Algebra: A Combined Approach*, 2nd

edition, by K. Elayn Martin-Gay, and published by Prentice Hall. This text also comes with the MyMathLab software.

Finally, we think it is instructive to include findings from a series of recent student focus groups that Miami Dade conducted to identify strategies that would improve the success of students in mathematics courses. They asked students who had successfully completed all of their preparatory math courses a series of questions concerning study and teaching strategies that they found especially helpful (Miami Dade Quality Enhancement Plan, August 2004). In terms of the students' own efforts, they stated that the most helpful techniques were:

- Staying up to date in class;
- Using available resources;
- Studying with others informally and in groups;
- Having a positive attitude.

In terms of successful teacher strategies, they noted:

- Empathy toward the students;
- Use of a variety of teaching techniques;
- Explanation of topics in different ways;
- Time to practice in class;
- In-class study groups;
- Several exams.

***Mount San Antonio Community College*[33]**

Mount San Antonio Community College (Mt. SAC), located in Walnut, California, is the largest single-district campus of California's 109 community colleges. Demographically, the college serves a large minority population; two out of three students are either Hispanic or Asian/Pacific Islander. In other respects, the college is fairly typical.

Mt. SAC's developmental math program is systematic in its course offerings, developmental student support, and professional development opportunities for faculty—all key elements of its developmental math program that warrant discussion. Two unique components of its program, the Math Academy and Math Activities Resource Center (MARC), are especially noteworthy because both have evidence of enhancing the success of developmental math students.

[33] Our point of contact is Deborah Boroch, Associate Dean, Natural Sciences.

Overview

Like other colleges in this study, Mt. SAC requires students to take placement exams before enrolling in their first mathematics course. They are, however, fairly different in their strategies. Similar to American River College, faculty at Mt. SAC have not been satisfied with the more traditional placement exams. Instead, a placement test authored, piloted, and validated by the mathematics faculty is used for placing students into elementary algebra. And while Mt. SAC currently uses the MDTP2 for intermediate algebra, a second test created in-house is being piloted.

Mt. SAC uses a collaborative approach in setting placement guidelines. A number of personnel, including representatives from the Mathematics Department and Student Services, review policies, find consensus, and send their recommendations to the Chancellor for final endorsement. This integrated collaboration in setting placement policies is a testament to the commitment Mt. SAC has, both inside and outside developmental mathematics, to ensuring the success of its students.

Mt. SAC also has a strong commitment to faculty professional development, for full-time as well as part-time staff members. In 2002-2003, about thirty math faculty received between four and twelve hours of targeted training in the areas of math success tools, cultural diversity and learning styles, project-based learning, applications of instructional technology, classroom assessment techniques, and whole-student development pedagogy.

Overall, specific staff development has been required for the past five years. Faculty members spend six hours each semester focusing on issues determined most important by the department. In addition, the college supports ongoing development opportunities and offers a Developmental Education Faculty certificate through a three-semester program.

This faculty training is important because of the comprehensive pedagogical approach Mt. SAC takes to developmental math. Courses include real-world problem solving also integrate interdisciplinary problems and collaborative learning. Further, courses are offered in a variety of methods to meet the needs of diverse learners. Elementary and intermediate algebra courses are offered in three formats: a traditional eighteen-week, semester-long, 4-unit course; a two-semester program in which the traditional course is divided into two 3-unit courses; and the Math Academy we cited earlier—an accelerated course in which students complete elementary and intermediate algebra (9 units) in one semester, with the added integration of exclusive support systems.

Math Academy

The approach of building elementary algebra and intermediate algebra into a one-semester Math Academy is unique among our selected colleges. As a part of the Math Academy, students enter a "learning community" program and are assigned to one of three cohorts of thirty students each, enrolled in two sections of math course work. Each cohort completes nine weeks of elementary algebra followed by nine weeks of intermediate algebra. The Math Academy has added support services, including student peer advisors, a supplemental instructor for each section, and a counselor that meets with the cohort weekly in a "community class" that is team taught with a math instructor. Community classes focus on content-specific and general college success strategies, including skills to improve test taking and to reduce math anxiety.

The learning community focus of the Math Academy is integrated into the instructional approaches as well. Instructors emphasize the importance of developing and using effective study groups. Together, students examine different methodologies and problem-solving techniques with their peers.

The Math Academy is an effective strategy in teaching developmental mathematics for several reasons. First, retention in the Math Academy is higher than that of traditional developmental math courses.[34] In spring 2004, Math Academy retention was 100 percent, while traditional course retention was 79.1 percent for elementary algebra and 83.2 percent for intermediate algebra. Student success is also higher in the Math Academy. The proportion of students earning a "C" or better in the Math Academy during the spring 2004 semester was twice that of students in traditional developmental courses (50.7 percent versus 23.6 percent, respectively).

The Math Academy is also more successful in reaching high-risk students (i.e., repeaters, students on academic probation) than traditional math sequences. This is significant because course evaluations show that overall satisfaction with the program is high and, according to Mt. SAC, student comments often indicate a major shift in their approach to college as a whole.

Other Student Support

Support services for developmental math students do not end inside the classroom. Mt. SAC makes multiple resources available to all developmental mathematics students free of charge, including Supplemental Instructors, tutors, Learning Assistance Center, and the Math Activities Resource Center.

---

[34] Traditional math courses would include Elementary Algebra and/or Intermediate Algebra taught in the semester-long, eighteen-week format or in the two-part, two-semester program.

As previously mentioned, supplemental instruction is an integrated component of the Math Academy. However, traditional developmental mathematics courses are increasingly able to use Supplemental Instructors (SIs), using Title V funding, in addition to other resources. For instance, in spring 2003, SIs were employed in 11 sections of developmental math courses, and Mt. SAC has found that students in these sections had measurably greater success than those without SIs.

Outside the classroom, Supplemental Instructors support student learning through study sessions designed to complement classroom lessons. Rather than simply repeat the lectures, SIs use methodologies that promote collaborative learning and allow students to rely on their abilities and help each other succeed. From time to time, SIs and math faculty also conduct a series of topical workshops for students. Success of students who participate in these workshops also shows an increase.

Similar to most of our other colleges, tutors are readily available at Mt. SAC. Free tutoring is offered at the learning assistance center for all Mt. SAC students on a drop-in and one-on-one basis. Mt. SAC is now experimenting with an online tutoring strategy. Students participate in the program by installing software at home and join in live discussions.

The tutoring program offers various levels of training for peers and professionals. A basic one-unit course, offered through the Education Department, is required for students interested in becoming peer tutors, with an additional one-unit course specific to mathematics tutoring that is required for employment as a math peer tutor. Professional tutors in mathematics have at least a bachelor's degree in the field.

Math Activities Resource Center

As we noted earlier, a second particularly noteworthy component of Mt. SAC's developmental math program is the additional support provided in the MARC. Designed for developmental math students enrolled in any pre-collegiate math course, students can only use the center by registering for the no-credit lab course. MARC allows for drop-in access to specially trained tutors, computer-assisted tutorials and practice activities, videos, and CD-ROMs. Staffed full-time by a member of the Math Department, the center offers texts, student solution manuals, and accompanying video series; resource sheets and final exam reviews; graphing calculators and other equipment; tutorial software; and MyMathLab online. MARC also provides space for study group activities and meeting space for periodic office hours with instructors.

The center maintains liberal hours of operation and is used widely by students. During fall 2002 and spring 2003, MARC served more than 3,500 students, with

related tutoring equaling nearly 61,000 hours. As of fall 2003—just two years after opening—the center drew in 26.2 percent of all developmental mathematics students. Statistics indicate that time students spend in the center is an important component to student achievement. The overall success rate for students in developmental mathematics courses who use the center at least five hours in a semester is 12 percent higher than those who do not. Mt. SAC regularly assesses student satisfaction with the MARC, and results indicate that the center reinforces students' classroom learning. They also express concerns about succeeding in their courses without the center's resources.

The enhanced success of students enrolled in the Math Academy lends support to the belief that some, or perhaps all, of these strategies that are shared by several colleges in our study do contribute to the success of students through developmental math. Specifically, we note the use of study groups and peer collaborative learning, providing students with study skills, math anxiety reduction strategies, supplemental instruction, and ample support in terms of tutors and other supplemental aids.

Northwest Vista College[35]

Northwest Vista College (NVC), in San Antonio, Texas, is a relatively new college that officially opened in 1995. Compared with other colleges in our survey, it serves a moderate-sized student population that is largely Hispanic and fairly young, and that experiences a low poverty rate. According to the CCSSE survey results, a significant percentage of the student body aspires to obtain a four-year degree (figure 13).

Our selection of NVC is based on a number of particularly noteworthy practices in developmental mathematics, including an Advocacy Center[36]; a campus-wide commitment to cooperative and active learning; training that all faculty receive, including adjuncts; and a Math Lab for Cooperative Learning. These and other practices were responsible for NVC receiving the MetLife Foundation Initiative on Student Success Best-Practice Colleges award in 2003-2004 (CCSSE 2004).

The NVC faculty and staff are committed to creating an open, student-centered culture that emphasizes active and collaborative learning. Cooperative learning labs are just one way in which the college has committed to the learning experience, particularly for developmental education students. One example is the Math Collaborative Learning Groups, a program to aid developmental math success.

---

[35] Our point of contact is Anna Harwin, Math Coordinator.

[36] Prior to fall 2004, the Advocacy Center was called the Math Advocacy Center. Since then, the center extended its services to include developmental reading and developmental English, and to provide a tutoring service for underprepared students in college-level courses.

An important component of all teaching at NVC is the tenet that it is a student-centered institution. To that end, NVC is committed to providing faculty training in cooperative and active learning (CCSSE Highlights, Volume 3, Issue 5, 2004(b)). Adjunct faculty members are also encouraged to attend the training; in fact, NVC pays adjuncts to attend training in cooperative learning and critical thinking. This philosophy plays a large role in several of the elements of the developmental math program.

Successful Strategies

Programs of study at NVC are defined by clusters, and developmental courses are under the Academic Foundations Cluster. Developmental math is led by a math coordinator, who is under the direction of the Academic Leader of the Academic Foundations Cluster. The Academic Leader is a math faculty member who, among other duties, provides leadership and mentoring of part-time faculty members, including interviews, regular orientation sessions, training sessions, and various forms of evaluation and communication. Because adjunct instructors teach about 40 percent of the math classes, this close mentoring and supervision by a full-time faculty member is an important component of the NVC developmental math philosophy. NVC faculty work hard to ensure uniformity in the curriculum and adherence by all instructors to the education philosophy of NVC in terms of instruction and other basic education tenets. For adjuncts, this includes a group orientation session in which instructors are given information concerning expectations and how students are to be treated, and separate training for the relevant developmental math course that is led by the course lead instructor. NVC makes a particular point of instructing all faculty never to tell students, "You should already know this," or to make other types of undermining statements.

Additional adjunct support comes from the policy that all full-time faculty members are assigned adjuncts to work with, forming what NVC calls "rings." The faculty member keeps in contact with his or her adjunct faculty members using face-to-face meetings, regular orientation sessions, training sessions, intra-ring evaluations, and e-mail correspondence.

In addition to the training that faculty receive concerning NVC's approach to learning, the college supports its student-centered philosophy with the option of an in-progress (IP) grade for students in developmental courses, something we have seen in a few other institutions. Specifically, an IP grade is given to students who have not mastered the level of developmental material necessary to pass the course but who have made a good faith effort to succeed. This grade is intended as encouragement to the student to continue his or her efforts (i.e., not drop the course), and, where necessary, try the course again. An instructor gives this grade to a

student he or she believes has a good chance of passing the course if required to take it a second time.

In terms of developmental math course offerings, NVC offers four levels: basic mathematics, introduction to algebra and geometry, elementary algebra, and intermediate algebra. Students are given the choice of taking the courses in the traditional lecture format or online. Most traditional lectures use collaborative classroom techniques.

In addition to two and one-half hours spent in class each week, all developmental math students are required to attend the Math Lab for Cooperative Learning at least one hour per week. Students can attend this lab at any time during the week and as many times per week as they want. Faculty members request that students go with fellow students in their developmental math course, and group work is strongly encouraged. During the labs, students work on homework or projects, and they may receive help from tutors who are in the lab for that purpose.

NVC has experienced a significant increase in the success of students in developmental math courses after implementing this requirement. In particular, the success rate in developmental math courses increased over 10 percent since the labs were first implemented in 2000, from 58 percent to 64 percent in 2004. Again, it is not possible to discern whether this increased success is due to the additional tutoring students receive in the lab, or in the enhanced learning that may be associated with group work. Since we have seen this outcome in a number of our exemplary colleges, we suggest that this is a topic that warrants further study.

While the philosophy underlying the developmental math program at NVC is that the first line of support begins in the classroom, students who are struggling can get group tutoring in the Math Lab for Cooperative Learning, as we noted, and students who are at risk can get individual tutoring and advising in the Advocacy Center. In addition, the latter provides strategies to help students remain in their developmental math classes. Several options may be presented: tutoring to catch up, changing math levels, or changing class time to help students whose work schedules interfere with their education. NVC is particularly accommodating for students with competing time commitments; classes are offered in flexible eight-week segments, weekend courses, regular classes that convene two or three days a week, and three-week math immersion courses.

While all of these strategies are noteworthy, NVC has several other practices that contribute to its success. In particular, NVC developed mission statements reflecting outcomes for each developmental course, with standard objectives that must be met before continuing in the math sequence. To ensure consistency, faculty members use common syllabi and course calendars. And the last course,

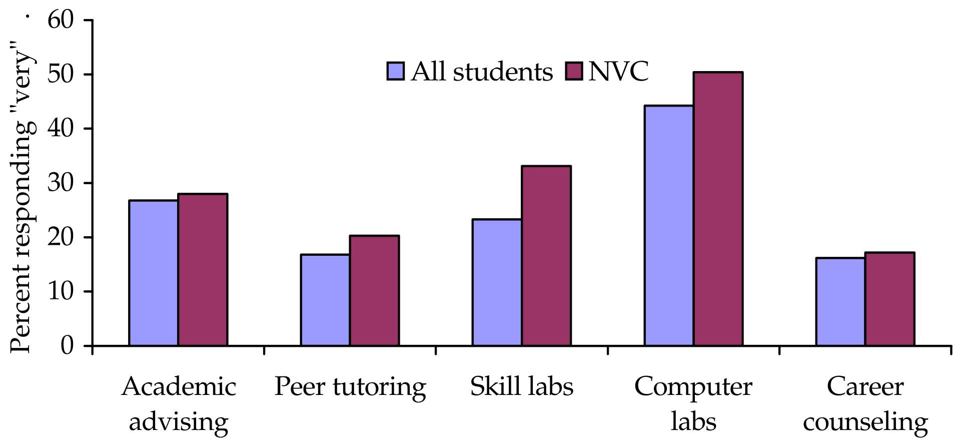
intermediate algebra, is a capstone course, encompassing the entire developmental math curriculum. In that course, instructors seek to identify any student with math deficiencies, since it is better to identify and correct them before the student attempts to take a college-level math course.

NVC's curriculum is constantly being evaluated, and success rates are reviewed frequently to ensure that they do not change significantly from one level of developmental math to the next. Further, faculty members use data on subsequent success in college-level math to ensure that developmental students perform as well in college algebra as students who did not require developmental course work. And developmental math faculty work closely with Student Success, the center for student services, to plan classes in response to student needs and to help evaluate placement scores and evaluation instruments.

We report a number of interesting findings for NVC from the CCSSE survey. In particular, the students appear to be more satisfied with the college in general, and the academic services in particular, than students at other institutions (figure 17). Specifically, 21 percent more NVC students say that they are very satisfied with peer[37] tutoring, 42 percent more with skill labs, and 14 percent more with computer labs than all students responding to the CCSSE survey. In contrast, compared with their peers, a smaller margin of NVC students report that they are very satisfied with academic advising and career counseling. The larger margin of satisfaction for the first set of services may be an indication that NVC's approach to them, especially the Math Lab for Cooperative Learning—a skill lab that includes tutoring—resonates particularly well with developmental mathematics students. Finally, 32 percent more NVC students than the average for all students completing the survey say that their entire education experience was excellent.

[37] Tutors may include students in college-level mathematics courses, and all tutors in developmental mathematics are paid, and are College Reading and Learning Association (CRLA) certified, which we define in a later section.

Figure 17: Satisfaction with NVC services



Source: CCSSE 2004.

Onondaga Community College[38]

Onondaga Community College (OCC) is part of the State University of New York (SUNY) system, located near the city of Syracuse. In terms of demographics, it serves a medium-sized student population that is slightly younger and more racially homogeneous than the national average. OCC's student body is also somewhat poorer than the average; about half of all matriculated students receive Federal grants.

OCC has a comprehensive approach to developmental mathematics that draws heavily on the recommendations put forth by AMATYC in the *Crossroads* document but also goes well beyond. The OCC program has several noteworthy components, which we describe here, including placement policies, grading policies, use of software in traditional lectures, approach to online courses, and support systems for developmental students.

We turn first to placement policies since OCC's approach to developmental mathematics begins before the student ever sets foot on the campus. Similar to the other colleges selected in our study, OCC requires all entering students to complete placement testing before enrolling in their first mathematics course. However, our research has found OCC to be unique in that all students are mailed review sheets before taking these exams so that they can refresh their skills. One study that we

[38] Our point of contact is Sharon Testone, Professor, Mathematics Department.

cited in our literature review found this practice to be very effective in reducing the number of people required to take developmental mathematics, and resulted in no detrimental effect on their success in their first college-level math course (Revak, Frickenstein, and Cribb 1997). OCC has found similar results.

OCC goes even further; students who believe that they were placed incorrectly have the opportunity to have their results reviewed by a trained Mathematics Diagnostician as part of their Mathematics Diagnostic Program. Based on this review, the student may stay in the course determined by the original placement test, immediately be placed in a higher course, or be given review materials and asked to return at a later time for additional testing. This review process has become more and more popular, growing from just 85 students in the 1987–1988 academic year to 1,223 students in 2002–2003. An analysis using a random sample of students enrolled in the fall of 2000 found that 65 percent of students placed in beginning algebra using the math diagnostic program were placed into a higher-level course. Of those, about one-third were immediately cleared to enroll in a higher level course, and the remainder completed their review of beginning algebra skills material provided by the diagnostician before being cleared to enroll in a higher level course.

In total, 344 students in the fall of 2002 were able to complete beginning algebra by working independently through the Mathematics Diagnostic Program.

The benefits of this component of their placement testing also accrue to those students not placed at a higher level of math. OCC has found that many students, after looking over the review problems, do not return to retest because they realize that they are actually in the right developmental course. Those students have a better attitude about their placement and are more likely to remain in the course.

OCC also has several pedagogical approaches to both beginning and intermediate algebra that are either innovative or reinforce research we reviewed. For instance, both courses have been revised in response to the AMATYC *Crossroads* standards to include real-world problem solving and to incorporate statistics. They also incorporate interdisciplinary problems, and most instructors use collaborative learning. Similar to a few of our other colleges, OCC requires skill mastery of its developmental math students throughout the course, instead of just an overall passing GPA. Students must receive at least 80 percent on each test or quiz, as well as on the departmental final, to enroll in the next higher course. This skill mastery also translates to a passing score requirement of a "B" versus the more common grade of "C" or better in developmental math courses.

The skill mastery requirement is a strategy that warrants further study. While such a policy might reduce the pass rate of students within the developmental course itself, it could enhance the pass rate of students in higher-level math courses,

resulting in fewer students transitioning out of developmental math, but more of those who do successfully completing a college-level math course. The lower within-developmental course pass rate could potentially be mitigated with other strategies, some of which we will discuss.

One such strategy of enhancing the pass rate of students in developmental math courses, and one that we have found to be unique to OCC, is the after-semester workshop. As background, OCC noted that many students who fail a developmental math course do well in the first part of the semester, only to have difficulty toward the end. Instead of having such students repeat the entire semester, as is typically required, OCC developed workshops that consist of eight days of three-hour intensive classes held during semester vacations. Instructors must refer their students, but the workshops are intended for students who have mastered most of the material. At the end of the workshops, students must pass the final departmental exam with a minimum grade of 80 percent.

These workshops have produced consistently high pass rates—nearly 95 percent and 85 percent of elementary algebra and intermediate algebra workshops students, respectively. These students also do well in higher-level math courses; 76 percent who passed the final exam obtained at least a "C" in their liberal arts mathematics course. OCC attributes some of the high success rate of these workshops to small class size (12 to 15 students), self-paced review packets, and in-class problem-solving sessions. However, it is difficult to net out the fact that, in large measure, only the most dedicated and motivated students attend these workshops. Further, because these workshops take place during college vacations, these students benefit because little time has elapsed since they last saw the material, and there are fewer distractions from other course work. Likewise, these workshops would not be possible without the commitment of faculty willing to devote time during semester breaks, and the commitment of the college to providing the resources necessary for students to attend the workshops.[39]

OCC's use of software in courses is also noteworthy because it has found ways of using the technology to its advantage, a fairly unusual finding based on the discussions we have had with numerous faculty at other institutions, as well as the conclusions of a number of studies we reviewed. The software is used most extensively in the online and newly piloted computer-enhanced courses.

OCC offers a number of online sections of both beginning and intermediate algebra, and each follows the same basic structure. The courses are composed of instructor-written lessons, textbook assignments, and CD-ROM videos provided by

[39] Students pay a nominal $10 fee for materials, and faculty members are paid to teach the workshop. The college is reimbursed by the state for the cost of the course.

the textbook publisher. Students are required to take tests online, and to take a proctored departmental final exam.

Perhaps the most important component of OCC's online strategy is the requirement for students to complete all homework online at the publisher-developed Web site, using MyMathLab.[40] This was based on lessons learned from its first experiences with online beginning algebra in the fall of 2001. That semester, the pass rate was 40 percent, which OCC deemed to be unacceptable. That's when the college started requiring students to submit all homework online. The benefit of that strategy is that the software allows students to view a sample problem and complete a problem with computer guidance before attempting the homework problem. Students must earn a score of at least 80 percent on each homework assignment, although OCC has found that many continue to work on it until they reach at least 95 percent. Currently, the pass rate for online beginning algebra ranges from 75 to 88 percent, which is far higher than the pass rate for any on-campus section of either beginning or intermediate algebra.

Building on that success, OCC piloted a number of Web-enhanced sections of beginning and intermediate algebra this spring. The students meet the full number of hours in class with the instructor but must complete their homework using MyMathLab. The college reports that the instructors are very pleased with the results and that students perform much better on their exams than they do in the traditional sections. Because the semester is still in progress, OCC cannot report on any metrics of success for these Web-enhanced sections.

Finally, we highlight the support systems that OCC has for both developmental math students and their instructors. In particular, OCC has had a math lab for 25 years, growing and expanding its services continually. Developmental math instructors are urged to bring their students to the lab during the first week of classes for an orientation session, in which students are informed of the hours for tutoring and the types of tutors available (both peer and professional). Each semester, the Math department evaluates the lab and tutoring services. In addition, the college has been able to determine that students who use the tutoring services perform better in developmental math courses than students who do not. Finally, OCC recently began small group tutoring and study sessions for students who were having difficulty in the classroom. Attendance is voluntary, but many students take advantage of the opportunity.

In addition to surveying satisfaction with the math labs and tutoring services, OCC administers evaluations of all developmental math courses, software packages,

[40] We discussed MyMathLab in a previous section. This is software that accompanies a number of textbooks published by Pearson Education.

and the after-semester workshops. It uses responses to all of these surveys to constantly modify the courses and support systems in order to better respond to the changing demands of the students and the rapidly changing technology. OCC's commitment to staff development is also quite evident; both full-time and part-time faculty meet each semester to discuss changes in curriculum, new software, concerns with pedagogy, and other matters. In addition, each month faculty meet for "Math Dialogues," some of which have dealt specifically with developmental math issues. Members also present information they have learned from AMATYC and other conferences. Further, all adjunct and full-time faculty are invited to the presentations made by textbook sales representatives and technical specialists who demonstrate the latest technology and pedagogical enhancements. Finally, each developmental course has a lead instructor who is responsible for providing updates to all faculty teaching the course. Often, small groups of faculty meet to discuss innovative approaches to teaching developmental math students.

Zane State College[41]

Zane State College (formerly Muskingum Area Technical College), in Appalachian Ohio, is unique among our colleges for a number of reasons. In particular, Zane State is a two-year technical college; the main objective of the college's degrees is employment rather than transfer to an advanced degree. This may be one reason why the graduation rate is almost twice the average national rate for public two-year colleges. As we discuss, however, this high graduation rate is also the result of a number of strategies that Zane State uses that have been developed specifically to address both retention and success in developmental courses.

Zane State is the smallest college, the most racially homogeneous, and the poorest population of our selected colleges and, indeed, of the nation. According to personnel at the college, the student population is disproportionately composed of poor single mothers, faced with unusually high unemployment. For reference, the U.S. unemployment rate in 2004 was 5.5 percent; Zanesville Ohio's was 9.0 percent (Bureau of Labor Statistics 2005).

In addition to these challenges, a large number of incoming students require developmental courses of all kinds. One of every two students places into Basic Computation—a course covering basic arithmetic topics—and virtually no one places into a course that is above an intermediate algebra level.

The combined financial, family, and academic difficulties are perhaps the main reasons that Zane State students had lower than average retention and graduation

[41] Our points of contact are Rebecca Ament, Director of Developmental Education, Becky Kellum, Mathematics Department, and Becke Butler, Mathematics Department.

rates during the middle to late 1990s, when Zane State initiated several programs that specifically addressed developmental education and retention. These strategies are noteworthy because they have had a significant effect; the success rate of developmental students in general education courses has increased by 50 percent, whereas the retention rate has increased 10 percent (CCSSE Highlights Vol. 3, Issue 4, 2004). In fact, the college's efforts won it recognition as a 2003-2004 MetLife Foundation Best-Practices College in student retention.

The principal features of Zane State's strategies include a developmental mathematics curriculum that has received certification from NADE, a certified tutoring program, use of the Noel-Levitz Retention Management Program to identify high-risk students, a required freshman orientation course, extensive use of academic advisors, mastery learning requirements, cumulative exams, and advanced degree requirements for instructors. We discuss these next.

Zane State's strategies begin before students start their first class. As part of its admission process, all students (except transfer students) are required to take the ACCUPLACER placement exam and the Noel-Levitz Retention Management System/College Student Inventory. This latter inventory is administered to identify academic or affective characteristics that are associated with a high likelihood of attrition. No other institution that we contacted mentioned this test, but, according to the Noel-Levitz Web site, 500 postsecondary institutions use its Retention Management System to "increase student success, improve student retention, and enhance advising effectiveness" (Noel-Levitz 2005).

After testing, all students meet with an academic advisor in Zane State's Student Success Center. The advisor counsels them as to the appropriate courses to take as a result of the placement test and recommends support services that would be beneficial based on the results of the Noel-Levitz test. Students who score below a certain cutoff on the reading component of the placement test, or those identified through the Noel-Levitz test as being weak in their study skills, are advised to take a four-credit study skills course the first quarter. The Noel-Levitz test also helps the advisor to identify other support services or counseling that would be beneficial.

Zane State's academic advising system goes beyond this testing, and is one of the strongest that we found. All developmental students are assigned an advisor in the Student Success Center to help them with academic planning, registration, and other academic issues. Instructors notify these advisors if a student has excessive absences or has poor academic progress. The advisor, in turn, may recommend that the student take advantage of the tutoring services, or may offer other advice to overcome difficulties, both academic and personal.

In addition to academic advising, all incoming students, regardless of

developmental course requirements, must take a one-credit hour orientation course in their first quarter to help foster relationships with peers and faculty, learn about college processes and resources, and guide them in their career decisions. Incorporating lessons learned from the five years the college has been conducting this course, it has revised the course for fall 2005 to include a greater emphasis on the use of computers at Zane State, especially e-mail accounts, how to access the library and academic journals, how to use the Internet, and how to use Blackboard—an academic Internet-based communication and e-learning system that is used by numerous colleges. The orientation course provides campus tours, registration and academic advice, and career counseling. The latter is an especially important component. Students who indicate a career choice when they enroll are required to access the Ohio Career Information System to explore their chosen career field, including information about salaries and job prospects in various Ohio locations. Students who are undecided must complete a career assessment and planning inventory developed by Career Dimensions, called Focus that helps them in their career planning.

The emphasis on career planning and goals is an important component of Zane State's strategy. According to research summarized on the CCSSE Web site, students who have clearer career goals and aspirations may have higher persistence rates than those who do not, and Zane State has a number of strategies that help students identify and research various career fields. But their orientation course helps in other ways that may also be beneficial to retention and overall success. In general, the goal of the course is to have students understand and reflect on their learning styles, their short- and long-term goals, and their intrinsic motivation for being in college. As we note later, all of these strategies have resulted in a high level of satisfaction for students at Zane State.

In addition to its orientation and counseling services, Zane State makes extensive use of tutoring services, both professional and student. And the College Reading and Learning Association (CRLA), an accrediting body that is endorsed by a number of leading organizations, including NADE, has certified its tutoring program. According to its Web site, over 700 colleges and universities in the United States and Canada have been certified, but Zane State is one of only two colleges in our survey that noted CRLA certification. The purpose of certification, according to CRLA, is twofold: (a) recognition of institutions' programs and (b) establishment of standards of skills and training for tutors (CRLA 2005).

While the focus of our research has been on beginning and intermediate algebra, since half of all incoming Zane State College students place below this level—into Computational Math—a description of some of their noteworthy practices in these courses is necessary. Indeed, because so many students begin their math courses at this level, their strategies at this lower level may be largely

responsible for enhanced success at higher levels.

First, as we noted, Zane State's developmental math program has been certified by NADE at the advanced level, something that only eight other colleges have attained for their developmental course work generally, or specifically for developmental math courses. According to NADE, advanced level certification "is awarded to a program component that demonstrates success in meeting the goals and objectives of the component through Advanced-Level as well as General data, and utilizes the results of data analysis for program improvement. Advanced-Level data answers the fundamental question: What impact does the program component have on students' short-term academic success?" (NADE 2005).

The commitment and effort necessary to receive both NADE and CRLA certification is unusual, and it is a testament to the level of effort and dedication in general that the college has toward ensuring the success of students. Individual math course strategies also contribute, however, which is where we focus our attention next.

Both the lowest level developmental math course, Computational Math, and the next highest, Pre-algebra, make use of the mastery skill, or mastery learning strategy, that we described earlier. In this case, students must receive at least 80 percent on each unit test; those who do not are given the opportunity to work on missed objectives outside the classroom with an instructor or a tutor. They are then given a second chance, within a short time of taking the first test, to take a different version of the unit exam.

The exit exam requirement for these courses also incorporates a skill mastery strategy. Students must score at least 70 percent on each subtest of the exit exam in each course to pass (basic computation has six units, pre-algebra has three). This requirement ensures a certain level of proficiency of students enrolling in the next highest math class, which has been found to have a significant impact on the success rate in those classes. In particular, after implementing this exit exam policy, and incorporating a policy that only students who passed basic computation with an "A" can enroll in college-level business math (those who do not must first pass pre-business math), the success rate in college-level business math increased almost nine percent.

Zane State's algebra courses also incorporate several intervention strategies. For instance, students who fail the algebra course cannot reenroll in the course unless they also register for a one-credit Math Excel Lab. This lab is offered only to students in introduction to algebra and algebra, and it is optional except for students reenrolling in algebra. The college has found that students who take the lab are much more likely to pass the course, regardless of whether they failed it previously, than

students who do not take the lab. However, relatively few students enroll when it is optional.

One section each of introduction to algebra and algebra offer a hybrid online option that uses Interactive Math by Prentice Hall. Students are expected to come to class, but they work at their own pace. This format does not work that well, primarily because the college can't get students to pace themselves and keep up with the material. As a consequence, the instructors now contact each student registering for the course to ensure that they understand the level of commitment and self-discipline that is necessary to enroll in a self-paced course. Regardless, some students without the necessary motivation still enroll in the course.

Both of the full-time instructors for these algebra courses encourage students to work collaboratively, and they incorporate real-world and interdisciplinary problems into the courses. They also highly recommend study groups and have been proactive in establishing faculty-facilitated study groups for some of these courses. And all developmental instructors must have a middle or high school teaching license and experience in the subject area they teach. Math instructors in nondevelopmental courses are required to have Master's degrees, with either a concentration or eighteen graduate hours in mathematics.

A fairly large proportion of developmental math students succeed in their courses at Zane State. In particular, 73 percent of students in Basic Computation or Pre-algebra receive a "C" or better, and 77 percent in introduction to algebra receive a "C" or better, as do 70 percent in algebra.[42] And 66 percent of the students in introduction to algebra who took pre-algebra first receive a "C" or better.

Zane State College has one of the most proactive advising and assessment programs we surveyed, and it is unique among our colleges in seeking and receiving certification for both its developmental Math and tutoring programs. Compared with many of the colleges in our survey (and perhaps the nation), Zane State may be in a better position to devote more resources, especially in terms of advising and placement, mandatory orientation and emphasis on career planning, small classes taught by highly educated and high-quality instructors, and specialized testing to identify at-risk students, because it is such a small campus. There are tradeoffs in these expenditures, but they appear to contribute significantly to the success of Zane State College students in general, and especially in developmental mathematics.

Precisely how do these support systems, developmental math strategies, and commitments translate into student outcomes? First, Zane State has been able to

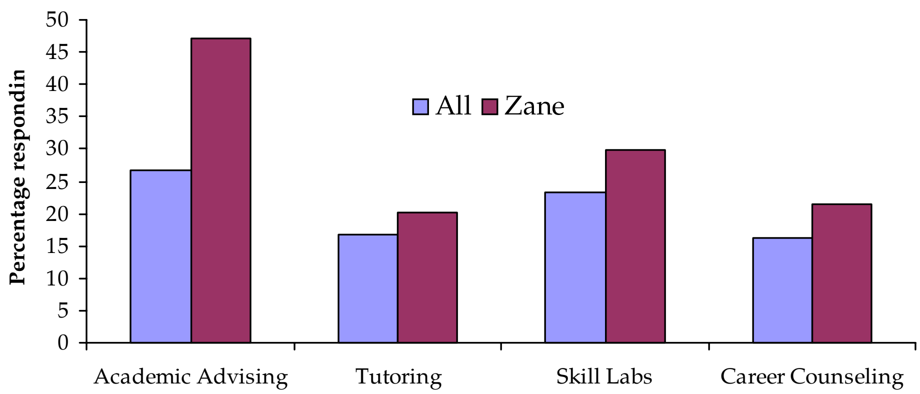
---

[42] These statistics net out students who withdraw from the course, which is allowed up to the seventh week of the eleven-week quarter (ten weeks of instruction, one week of finals).

significantly increase retention since implementing many of these measures, and its graduation rate is almost twice the national average for public two-year colleges. Precisely which of these strategies or combination thereof is responsible is difficult to determine, but we refer again to the CCSSE for some additional insight. Figure 18 contrasts the responses of Zane State students to all students participating in the survey in 2003 or 2004 to key questions related to these strategies.[43] In particular, we note the percentage of students responding "very" to questions concerning their level of satisfaction with a number of student services.

Across these measures, a much larger percentage of Zane State College students state that they are very satisfied with the services compared with the average student. The greatest discrepancy is in academic advising; 75 percent more Zane State students are very satisfied than the average community college student. Almost one-third more are very satisfied with career counseling, 28 percent more are very satisfied with skill labs, and almost 20 percent more are very satisfied with tutoring.

Figure 18: CCSSE findings: Comparison of Zane responses to all students



Again, it is difficult to ascribe the increased success of Zane State College to one particular strategy, but clearly its approach has resulted in a largely satisfied student body, which in large measure is able to meet its academic goals.

Other Noteworthy Programs

In the course of our research, we corresponded with dozens of faculty members and college administrators, and we reviewed numerous research documents. Absent scientifically based evidence, our goal was to narrow the list of colleges to those that had the strongest evidence of successful strategies in developmental mathematics and that, for the most part, were supported by published research in the field of

[43] These responses are for all students, regardless of age, developmental course status, number of credits, and so on.

developmental education in general, and developmental mathematics in particular. That process meant that we had to eliminate programs that did not have sufficient data, were too narrowly focused, served an unusual population, or were in too preliminary a stage. Even so, some of these practices may resonate well with educators serving a nontraditional student body or one that has a different set of goals than the more traditional programs. And some may warrant revisiting in the future as more students progress through the program. We have selected three of these programs to briefly discuss here.

Harrisburg Area Community College[44]

Harrisburg Area Community College (HACC), located in the capital and surrounding areas of Pennsylvania, warrants discussion because it highlights an important line of research to pursue in the future. In particular, HACC calculated the success rate of students in its developmental math program using fairly simple statistics. The process stops short of answering some key questions that a scientifically based study, using multivariate regression analysis, might be able to address.

Using an Analysis of Variance (ANOVA) procedure, researchers calculated the difference in the success rate (defined as the percentage of students enrolled receiving a "C" or better) in developmental math courses. The calculation controls for a number of student characteristics, including gender, age, race/ethnicity, and campus branch (Lum 2003). The most consistent result, across all developmental math classes, is that success is positively correlated with age. For instance, the success rate for students enrolled in algebra I in the fall of 2000 was 55 percent for students less than 20 years of age, 51 percent for those 20 to 24, 68 percent for those 25 to 29, and 61 percent for those 30 and older. The results are similar for those enrolled in algebra II; pass rates were 54, 56, 68, and 75 percent for the same age groups, respectively. The greatest increment in success rate in both courses occurs for those age 25 and older.

The results persist even when other characteristics, such as race/ethnicity, gender, and branch of campus, are included in an ANOVA model. For both algebra I and II, age is a significant factor in determining success, even when differences in other student characteristics are held constant.

Recall that American River also reports that older students have a higher success rate than do younger ones across all courses that offered Beacon, again with the greatest increment in success occurring around age 25. The HACC results take this a step further; controlling for other characteristics, and confining the results to developmental math courses, older students still outperform younger ones. Why is

---

[44] Our point of contact is Linda Myers, Associate Dean, MSAH, HACC.

this so, particularly since, according to the CCSSE findings cited previously, older developmental students report that they are more likely to withdraw from college due to financial and family concerns and require more services (e.g., advising, tutoring, and skill labs) than younger developmental students? In addition, younger students have the advantage of having covered some of the developmental math material in high school—a more recent experience than for older developmental students. However, this effect may be mitigated somewhat by the fact that older students tend to enter community college with more postsecondary education than younger students.

Is maturity the most important factor in determining the enhanced success of older students, or is there something different in the approach that older students take to their studies? Does the fact that they report that support services are more important to them mean that they avail themselves more of these services, and is it the services that are responsible for their enhanced success? Do older students begin their college education with better study habits, better time management skills, or better note-taking skills? In other words, are they more knowledgeable about "how to learn"? Do they make greater use of supplemental instructional aids, such as software that accompanies the text or videos of the lectures? Or do older students simply have a greater commitment and motivation in pursuing their academic goals? Knowing more about why these differences exist could be beneficial for all developmental math students. Certainly, not all of these factors can be addressed by developmental math educators, especially maturity and commitment, but many factors can be, and often are, addressed in the colleges with the most successful strategies.

Some clues to the precise causes of the differentials in success may be found in the particular pedagogical approaches and student services offered by HACC. If HACC provided few support services to developmental students, it would be fairly easy to dismiss differences in the use of student services as one contributor to the enhanced success of older students. On the contrary, HACC provides students with a number of support services. In particular, students have access to free peer and professional tutors 12 hours a day. HACC also targets developmental math students for group tutoring, all students have access to "student success" workshops, and a special class titled "Building Self-Confidence in Mathematics" is offered each semester.

There is little variation in instructional methods, which would tend to rule that out as a source of differences in success rates. Most sections of developmental math courses are taught in the traditional lecture format, with a limited number of sections offered in the computer lab using the Academic Systems software. MyMathLab software, provided to all students in both the traditional and online classes, is used to supplement instruction and provides students with guided solutions outside the

classroom. Regardless of delivery method, all sections of each course follow the same syllabi using the same book. Although no departmental final is offered, faculty members report that they are working toward that goal.

Do older students make greater use of the services offered by HACC, or do they use MyMathLab more extensively? Do they enroll in the self-confidence course at higher rates? Answers to these questions are not available; in fact, the data for such an analysis may not exist. However, collection of such data and estimation of the magnitude of their effects on success, while controlling for other factors, would be a useful step in developing services and developmental mathematics curricula that enhance the success rate of students across institutions.

***Kapiolani Community College*[45]**

Kapiolani Community College (KCC) in Honolulu, Hawaii, is an example of a larger group of community colleges that offer an alternative developmental math sequence for students intending to major in fields that do not follow the more traditional math sequence, which includes college algebra. In our research, we noted that a number of community colleges offer such an option, which may be a better alternative for students who know what major they wish to pursue when they first enroll because it tailors the math content to their chosen career fields. It also allows targeting of examples and real-world problems to the types that these students would most likely experience in their jobs. In addition, it may enhance success for these students if the more difficult material covered in college algebra is not required of them. Finally, at least in the case of KCC, students choosing this path are able to satisfy their developmental math requirements in one five-credit course completed in one semester, compared with traditional students who must take two three-credit courses spanning two semesters.[46]

Specifically, KCC has created a combined introductory and intermediate algebra course that meets four hours per week in lecture, and an additional two hours in either lecture or lecture and lab. The course makes extensive use of group work, teaches problem-solving skills through real-world problems, and focuses on verbal and written communication skills more than the traditional two-course sequence of introductory algebra and intermediate algebra. The combined course also provides more opportunities for student assessment than the traditional sequence; students are given three midterms, eleven quizzes, twelve supplemental handouts, weekly graded homework, and a final exam.

Does the combined sequence result in higher success rates for students

---

[45] Our point of contact is Jill Makagon, Holomua Department Chairperson, Kapiolani Community College.

[46] KCC recently began offering a combined elementary and intermediate algebra course.

choosing this path? It is difficult to say what percentage of students who pass the combined course would have also passed the two-course sequence, although KCC has provided us with data that support the contention that the combined sequence does enhance the success rate of students who choose that option. Fifty-five percent of students enrolled in the combined course between the fall 2001 and spring 2004 semesters received a grade of "C" or better and were therefore able to enroll in their required college-level math course the subsequent semester. In comparison, students enrolled in the introductory algebra course, the first in the two-course sequence, had an average pass rate of 38 percent, and 43 percent of students pass the second course. Multiplying these two success rates yields an estimate of the probability that a student will successfully complete the two-course sequence in two semesters—16 percent, or roughly one-third the rate of those enrolled in the combined sequence.

There are tradeoffs in the approach offered by KCC and other community colleges. The risk, and hence cost, of this approach is that a student who pursues this path and subsequently switches to a major that does require college algebra may be ill-served because the alternative course does not satisfy the prerequisites for college algebra. In the case of KCC, these types of students are not necessarily worse off since those who have successfully completed the combined course in one semester are required to take just one additional course before enrolling in college algebra, imposing a two-semester sequence that would have been required had they originally chosen the more traditional path. The difference is that students who change their minds will ultimately be required to take eight credits of developmental math over two semesters, compared with the six-credit, two-semester requirements of those pursuing the more traditional path.

There are benefits to this approach as well. Requiring all students, regardless of their career goals, to attain the same level of math competency may not serve the student or perspective employer well, especially if more stringent requirements necessarily force less-prepared and more academically and financially challenged students to drop out at higher rates than they would if the requirements were geared more to their particular goals. As we noted earlier, employers are seeking students with critical thinking skills, who are able to communicate mathematics in a variety of ways and to work collaboratively—skills that are not sacrificed in the alternative approach offered by KCC.

We suggest that this is an area in need of additional research to address such issues as the number of students who ultimately change their minds and are required to take the second course in the sequence, what the success rate (and graduation rate) is of students who find themselves in that circumstance, and feedback from employers of students who pursued the alternative approach. Follow-up research could investigate whether the student possesses the knowledge and skills necessary to be an effective employee and to eventually progress into jobs requiring greater

math skills and greater responsibilities.

Northampton Community College[47]

Northampton Community College (NCC), in Bethlehem, Pennsylvania, is included in this section because of the materials used in one of its approaches to developmental mathematics. NCC has some evidence that these materials enhance the success rate of students going through the developmental math sequence.

Specifically, NCC offers three distinctly different instructional approaches to elementary and intermediate algebra: (a) traditional lecture, (b) computer-assisted, and (c) project-based courses using the Maricopa Math Modules. It is the last approach, which incorporates many of the recommendations made by AMATYC and others, that warrants mention here.

The Maricopa Math Modules were written by instructors primarily from Maricopa County, in the Phoenix area (Chandler-Gilbert College is part of that county). The project is the result of an NSF grant awarded in the early 1990s.

The modules are based on six student outcomes that guide the materials. In particular, the modules state that students should (1) Connect, (2) Reason, (3) Express, (4) Appreciate, (5) Tap into technology, and (6) Establish a foundation as they develop their math skills. These outcomes form the acronym CREATE (Maricopa District 2005).

Consonant with the recommendations of AMATYC and others, these modules incorporate more than just algebra; they include such topics as probability, sampling, geometry, and functions. There is a strong emphasis on learning through activities so that the math is put into context. This means that much of the classroom time is spent in structured activities, but lectures are also used when necessary.

Faculty at NCC indicate that the modules focus on problem solving, reasoning, communicating mathematically, connecting mathematics (teaching in context), multiple representations, and multiple assessments. NCC notes that this method fosters a conceptual understanding before considering procedural skills.

As part of the philosophy of the Maricopa Modules, students enrolled at NCC in these sections are assigned to a team and are expected to do some projects outside class with their group. This is an expectation that is unique to students in these classes; in general, study groups are neither encouraged nor required in classes using other delivery methods.

---

[47] Our point of contact is Dennis Ebersole, Professor of Math/Computer Information Science.

Students who enroll in these modules experience a higher rate of success, although we cannot account for self-selection. In particular, NCC states that 44 percent of students who first enrolled in the elementary algebra pilot in fall 2000 through spring 2002 received at least a "C" in both elementary and intermediate algebra. This compared very favorably with the rate for students in the traditional sections; only 39 percent passed both courses.

NCC notes, however, that while students enrolled in the Maricopa Module approach to elementary and intermediate algebra have a higher success rate through the two-course sequence, it has found no difference by delivery method in the success rate of students in the first college-level course. Even so, the higher success rate in the two-course sequence means that the Maricopa Modules result in more students prepared to pursue college-level mathematics.

These conclusions are based on fairly old data, measured when the modules were in their early stages of implementation at NCC. Further, as we noted, students self-select into each of these modules, resulting in some measure of bias in these results. Because they incorporate so many of the recommendations that we have found in the literature, as well as promising practices in the colleges we have included in this study, a more thorough analyses of the effectiveness of the Maricopa Modules is warranted.

Discussion

What can we conclude from the strategies employed by our exemplary colleges, and the supporting evidence they have that these promising practices enhance success? While none of the evidence we have described is based on RCT studies, the fact that many of these strategies are shared by these colleges, and are consistent with much of the literature we reviewed and with recommendations of AMATYC, The Diploma Project, and others, gives us confidence that they do, either in isolation or in combination, improve the success of developmental math students. But which strategies—in what combination, and for which populations—result in the most improvement? These are questions that are beyond the scope of this research, but are the fundamental questions that need to be addressed in future research in this area.

It is tempting to suggest that, absent research identifying which of these strategies is most effective, developmental math instructors should adopt as many as possible. But this ignores the fact that there are costs associated with these strategies and they accrue to both the student and the institution. For instance, while increasing the credit hour requirement of courses in order to incorporate labs or group activities may improve the probability that students will succeed, it also increases the cost of the course to students. This is less of an issue for full-time students, but, for those who pay by the credit hour, the increased cost may not be offset by the increased

probability of success. For instance, what if the additional course time disproportionately benefits just some students, such as younger ones? In that case, older students have been doubly burdened; in addition to increased tuition costs, they must now devote more time to school and less time to work and family, with little personal benefit.

Likewise, providing more counselors and tutors and adding instructors in order to offer study skills courses or to add study skills components to existing courses are enhancements that have financial consequences for the institution. Even so, we do not know the cost to the institution of considerable student failure in developmental classes or the cost to the individual of dashed academic and career goals, but we are assured that both are significant.

That is why it is so important that sound research be conducted to improve our understanding of which of these strategies is most effective, either in isolation or in combination, and for which types of students in particular. Such research is difficult to conduct, especially RCT experiments. Even so, scientifically sound analysis can be conducted in the absence of such experiments—research that measures as many extraneous factors as possible and controls for their effects in multivariate analyses. Our research has found that even this level of scientifically based validation of promising practices is fairly difficult; colleges often lack the data necessary to control for student characteristics, such as race, gender, age, and education credential, and are constrained by the inability to follow students if they transfer to other institutions. Nevertheless, much could be done with existing data to advance our understanding of which strategies are most effective, and perhaps even why.

Our research into these colleges with promising practices and documentation of what strategies are employed by each, coupled with our review of the literature and findings from the CCSSE and a number of other surveys, does allow us, however, to identify a number of salient themes that suggest strategies for supporting developmental math students and enhancing the success of a great majority of them.

First, our research indicates that the traditional lecture format remains the most prevalent instructional approach. While many colleges offer online options, computer-assisted courses, or some other hybrid mixture of delivery methods, we have not identified scientifically based research that indicates that these methods are demonstrably superior to the traditional classroom approach. In fact, many of our colleges report that students who enroll in online sections often have difficulty keeping up with the material, and generally do not possess the organizational skills and commitment that are necessary for this type of learning. Some colleges have found, however, that the incorporation of technology into the classroom, particularly with software that accompanies the text, is effective. We suggest that this is an area for future research, but for now we conclude that the use of this type of software may

enhance the success of some students if it is used in conjunction with other promising classroom pedagogical techniques that we recommend in this section.

Further, we deduce that the nature of computer-based instruction is counter to many of the strategies that appear to be most beneficial to students taking developmental math courses. In particular, recommendations from the literature we reviewed are supported by the consensus of practices in our exemplary colleges; students require a variety of approaches to learning. This means that instructors need to use a number of instructional tools to explain and reinforce the material, such as real-world examples, multidisciplinary examples, project work, traditional lecture, interactive computer software, and, especially important, collaborative group work. We have seen that students benefit by learning from each other, and collaborative learning can take place in many ways, both in and out of the classroom. The mechanisms by which learners benefit from each other is not clear, but group work allows students to see multiple approaches to problem solving, to ask questions in a less threatening atmosphere, to think about the subject matter more in depth when responding to peer's questions, and to communicate mathematics in multiple ways, especially verbally in response to peer's questions. Working in groups may also provide some students with the additional emotional support they require to stay engaged and enrolled in college.

The finding that students require multiple approaches to learning is why we suggest the use of technology in the traditional classroom: it provides one more approach to learning that may resonate particularly well with certain types of learners, especially when used in conjunction with a number of other approaches.

Second, there is substantial evidence that peer study groups are the most cost effective method for addressing many of the recommendations in this report. This approach is especially effective if it includes instruction in study skills, such as how to study for tests, note-taking skills, test-taking skills, organizational skills, and setting priorities, which we find to be an essential component of developmental mathematics curricula.

Our remaining recommendations are as follows:

- Students should be assessed regularly to ensure they are keeping current and mastering the material. Assessment should not, however, make extensive use of paper-and-pencil, true/false, and multiple-choice exams, which have limited ability to assess necessary critical thinking skills. In addition to restricted use of quizzes and tests, examples of alternative assessments are group projects and presentations, homework, and problem solving on the blackboard either individually or in groups, with follow-up classroom discussions.

- Because mathematics is a discipline that builds on successive skills, skill mastery, which requires students to master each component of a course at a minimum threshold, helps to ensure that students do not progress to increasingly more difficult material until they have attained proficiency in lower-level material. It also provides earlier identification of students who are struggling in the course, allowing for more timely intervention.

- The more time students spend in learning the material, going over it with peers or in class, doing projects, and so on, the better they appear to do. Increased time on task can result from a number of activities, including longer class convenings, additional class labs, peer study groups, and tutoring. We do not know whether it is simply the additional time devoted to the study of the subject that is beneficial or if these other activities contribute. Nor do we know what the optimal amount of time should be. Based on these observations, however, it seems that the fairly common class convening of 3 hours per week is not sufficient.

- Mathematics instructors teaching the same course within an institution should use common syllabi and exams to ensure that all students have a consistent body of knowledge before advancing to the next level of mathematics.

- All students' math knowledge and skills should be adequately assessed before enrolling in their first math course, and this assessment should be used as the basis for placing students in the correct course. There is growing controversy about the adequacy of conventional placement exams to accurately assess students, which may require developing alternative instruments. Regardless of the instrument used, students should be provided with review materials and practice exams before administration of the test to differentiate students who simply need to refresh their skills from those who need greater skill development. Such assessment should also involve active student participation as much as possible. For instance, this may take the form of follow-up discussion of the results with counselors or math faculty. The more students understand why they are required to take developmental math courses, the more satisfied they are with that placement.

- Students should be afforded ample opportunities to practice their skills, both in and out of the classroom, and to use multiple approaches. Within the classroom that means that instructors need to allow sufficient time to illustrate examples on the board, to have students go to the board and solve problems individually and in groups, for groups to work on problems together in each class, and for the class to discuss their approaches so that students understand that there are multiple approaches to problem solving. Discussing results also reinforces students' skills in communicating mathematics in multiple ways. Further, these problems should incorporate interdisciplinary, real-world problems—numerous examples of

which are provided in the textbooks most commonly used.

- Some research indicates that students with clearer career goals persist at higher rates. Many of our colleges have found it beneficial to incorporate career exploration activities into the developmental mathematics curriculum.

- Accommodating competing work and family obligations of older students, which means making labs and tutors available for a generous number of hours, including evenings and weekends, is beneficial because older students report they are more likely to drop out of college due to the challenges presented by family and work commitments. And because these services are so important to them, students should receive an orientation that instructs them as to the types of services available, where the computer lab and tutoring services are located, what the hours are, and so on.

- Instructors should foster learning and support students by encouraging them to ask questions and to actively participate in class. This means prohibiting negative attitudes, such as telling students "you should already know this" or making students feel that they are asking too many questions.

- All instructors, adjunct as well as full-time, need specific training in classroom techniques that have the greatest evidence of enhancing success, such as collaborative learning techniques, student-centered learning that minimizes student math anxiety and promotes cooperative and active learning, project-based learning, learning styles, classroom assessment techniques, and so on.

These strategies are numerous and, in most cases, require significant resources and time to implement. There are also many ways to implement some of them, as we have seen in our colleges with promising practices. For instance, students may learn from each other in many ways—in classroom settings, in peer-guided study groups, in required or optional labs, and so on. Likewise, study skills can be imparted in many ways—in multiple classroom presentations as illustrated by Chandler Gilbert Community College, or in peer study groups, examples of which are provided by American River College and De Anza College.

Requiring students to participate in peer study groups, or otherwise requiring "more time on task" presents a dilemma: increased costs of additional class time may be disproportionately borne by particular groups of developmental students. Yet, if such strategies are shown to enhance the success rate of students sufficiently, the benefits could outweigh additional costs in terms of higher success. In other words, the additional 30 hours or so required per semester to participate in these groups could save students who would not have succeeded in the course without the groups well over 100 hours that would be required to retake the course (conservatively

estimating that a student spends a total of seven hours each week during a 15-week semester on each course, between time spent in and out of class), in addition to tuition costs incurred in repeating the course. And for some of these students, success the first time may mean the difference between earning a degree and dropping out of college altogether.

One solution is to require participation or extended class commitment only of those students with the greatest probability of benefiting from them. Unfortunately, we do not know who these students are. We refer, however, to the Noel-Levitz test used by Zane State and others, which may provide the opportunity to enhance our understanding of precisely which types of students would benefit most. In particular, an experiment could be conducted in which all students enrolled in an introductory algebra course are required to take the Noel-Levitz test, with each student randomly assigned to a peer study group or extended class convenings, or to the control group. Measures of each students' pre-class scores in the various components of the test, such as academic motivation and receptivity to support services, as well as other student characteristics (age, gender, education background) could then be used to identify which metrics are associated with the greatest benefit by participation in a study group.[48]

Finally, we want to emphasize the importance of faculty training in classroom techniques that have significant evidence of being the most effective and the necessity of including all faculty, both full- and part-time, in the training. Since many institutions utilize a large percentage of adjuncts, especially in lower-level developmental math courses, this training is especially important. In addition to providing specific training in pedagogical techniques, this training should serve the important function of ensuring that all instructors are familiar with the goals, objectives, syllabus, and other policies pertaining to both the course they teach and the college more broadly. We find the approach used at Northwest Vista College, including the use of faculty "rings," especially appealing.

---

[48] More precisely, we are suggesting a multivariate analysis that uses success in the class as the outcome variable of interest, with student demographic characteristics, Noel-Levitz measures, and whether or not they participated in the study group or extended classes as explanatory variables. Such an analysis would require a significant sample size—say, on the magnitude of 100 or more students.

BUSINESSES

Background

In our search for successful strategies used by businesses, we focused on two types of businesses: (1) those that provide training for their employees in mathematics or contract with others to provide such services so that employed workers will have enhanced skill sets and (2) those that provide services to people who are unemployed or seeking to upgrade their math skill level to improve their skill set, employment, and earnings.

Our exhaustive search leads us to the conclusion that, in general, businesses fall into one of two categories:

- *Does not provide basic mathematics skill training.* Recall the findings we cited previously; less than 10 percent of respondents to the American Management Association 2001 survey say that they hire applicants found to be deficient in basic skills (AMA 2001). Our own research yields consistent results. Even businesses that we interviewed that may have provided such training services in the past indicate that in today's economic environment they are not willing to invest in employees lacking in basic skill areas, such as mathematics.[49] Additional evidence of the lack of basic math skills training is found in the 2004 State of the Industry Report published by ASTD; almost one of every two employees receiving training in 2003 was in a management, executive, or customer position (ASTD 2005)—typically not the types of employees in need of extensive basic math skills training.

- *Provides some training in developmental math, but lacks any measure of the effectiveness of this training.* According to an ASTD study conducted a few years ago, just 3 percent of businesses responding to its survey indicated that they measure business results of training programs, such as reduced costs, higher quality, increased production, and lower employee turnover or absenteeism (ASTD 2000).

We are left, therefore, with little information about what successful strategies may be employed by the few businesses that offer basic skills instruction, and without any measure of the effectiveness of the various strategies employed by businesses.

Instead, we describe four different programs that provide basic math skills instruction at various levels and to varying extents, as examples of the types of training that some businesses are providing. The programs are:

[49] This outcome is consistent with the result from human capital theory; businesses cannot earn a return on investment in general skills training.

- KeyTrain, a computer-based, self-paced training curriculum designed to work with the WorkKeys employment system developed by ACT;

- ALEKS/Net-Tutor, an intelligent tutoring that offers individualized assessments, exercises, explanations, feedback, and coaching for courses that range from basic math to advanced calculus;

- RXTechSchool, a self-study program for people pursuing careers as pharmacy technicians;

- The Henry Ford Community College Adult Tech Prep Bridge program, an example of a Bridge Program provided by community colleges that is designed to provide the foundation for career-long learning, both on the job and in formal technical training.

KeyTrain[50]

In addition to the more familiar college entrance exam, ACT created a comprehensive employment system called WorkKeys, in which employers can identify skills necessary to perform various jobs and workers can assess their skills to perform these jobs and then receive training in job skill areas where they are deficient. KeyTrain, which we describe here, was developed by Thinking Media as a comprehensive computer-based training curriculum designed specifically for these WorkKeys job skills.

The KeyTrain system is designed to help learners renew and expand skills that they may have learned earlier but have not put to use. KeyTrain also helps users learn to use and express these skills in practical situations that they may see in typical jobs. It includes targeted, self-paced instruction, pre- and post-assessments, a complete learning management system, and an occupational job profile database. These components can be used to help people learn, practice, and demonstrate the skills they need to succeed in the jobs and careers they desire. KeyTrain is in use in a variety of settings, including community and technical colleges, secondary schools, businesses,[51] WorkKeys service centers, school-to-work consortiums, and by individual learners.

KeyTrain is administered by the organization purchasing the materials, so the responsibility for teaching the courses is a local decision. The system, however, is designed to be successful with (1) a limited amount of teaching, (2) a robust student

---

[50] Our point of contact is Sheila Boyington, Thinking Media.

[51] Some of the companies currently using KeyTrain are Goodyear, Chrysler, Owens Corning, General Motors, Dow Chemical, Amtrak, Kimberly-Clark, and M&M Mars (KeyTrain 2005).

management system allowing administrators to easily monitor student participation, and (3) a methodology for ameliorating a variety of learning concerns.

The KeyTrain series includes eleven different courses. We focus on the most relevant of these: Beginning Skills – Math, Applied Mathematics, and Locating Information.

The KeyTrain Beginning Skills course is a tool for those requiring additional assistance to master the fundamental math skills required for basic workplace literacy. Specifically, this course is intended to assist in the prerequisite skills that should be mastered before beginning the traditional KeyTrain curriculum series.

The KeyTrain Beginning Skills course is organized by a series of specific skill objectives. These objectives represent the individual components and building blocks required to learn and demonstrate basic math skills.

The series includes computer-based "pretests," or diagnostic tools for mathematics. The purpose of these tools is to estimate a person's skills in each objective and subsequently identify individual objectives for improvement. The pretest contains three to six questions in each objective. At the end of the pretest, the student will receive a score of "good," "fair," or "needs improvement" in each area. A score of greater than 75 percent is good; a score of greater than 50 percent is fair.

All reasonable attempts have been made to make the pretests as easy to operate as possible, but it is also understood that the judgment of a personal instructor may be helpful for assessing people with limited literacy skills. These pretests are intended as a helpful tool—not as a definitive measurement of a person's literacy.

The Applied Mathematics and Locating Information courses include pre- and posttesting of students. The pretest is used for determining where a person should begin in the KeyTrain lessons. Students already demonstrating basic skills capabilities above the lower levels of KeyTrain can be exempted from the lower-level lessons in the system through the pretests.

The pretest is adaptive, beginning with a number of lower-level questions, which gradually become more difficult. Once the user fails to demonstrate competency at a given level, the test stops and advises the user where to begin in the lessons. This avoids frustrating the user with questions he or she is not able to solve, and it saves assessment time.

Each tutorial lesson includes a posttest that covers the skills presented in that lesson. The test selects several questions at random from a database of appropriate

items. Therefore, different users working next to each other in a classroom will receive different tests, and an individual user can take the test a second time and receive a number of different questions.

Both the Applied Mathematics and Locating Information courses provide lessons on how to read and analyze data from spreadsheets, find details, and, most important, interpret and find relationships from data in spreadsheets. In addition, these courses include instructions on how various graphics can be used to display the data contained in spreadsheets.

There are five levels of difficulty in the Applied Mathematics curriculum; Level 3 is the least complex and Level 7 is the most complex. The levels build on each other, incorporating the skills assessed at the previous levels. For instance, in Level 3, students should be able to:

- Solve problems that require a single type of mathematics operation (addition, subtraction, multiplication, and division) using whole numbers;
- Add or subtract negative numbers;
- Change numbers from one form to another using whole numbers, fractions, decimals, or percentages; and
- Convert simple money and time units (e.g., hours to minutes).

In Level 7, students should be able to:

- Solve problems that include nonlinear functions or that involve more than one unknown;
- Convert between systems of measurement that involve fractions, mixed numbers, decimals, or percentages;
- Calculate multiple areas and volumes of spheres, cylinders, or cones;
- Set up and manipulate complex ratios or proportions;
- Find the best deal when there are several choices; and
- Apply basic statistical concepts.

The Locating Information course has four levels of difficulty. In Level 3, the least complex, students should be able to:

- Find one or two pieces of information in a graphic; and
- Fill in one or two pieces of information that are missing from a graphic.

In Level 6, students should be able to:

- Draw conclusions based on one complicated graphic or several related graphics;

- Apply information from one or more complicated graphics to specific situations; and
- Use the information to make decisions.

Table 12 contains the estimates provided by KeyTrain to complete the Applied Mathematics and Locating Information courses.

Table 12. WorkKeys estimated time of completion by level

Course name	Section title	Estimated time to completion
Applied Mathematics	Introduction and WorkKeys Introduction	1 hour
	Pretest	1 hour
	Level 3	8 hours
	Level 4	8 hours
	Level 5	8 hours
	Level 6	8 hours
	Level 7	8 hours
Locating Information	Introduction and WorkKeys Introduction	1 hour
	Pretest	1 hour
	Level 3	6 hours
	Level 4	6 hours
	Level 5	6 hours
	Level 6	6 hours

KeyTrain reports that its product lines experience a 98-percent renewal rate, and its Web site indicates that over one million students have used it in the past few years. Absent research into the effectiveness of the product, both of these factors may be an indication of the quality of the curriculum, the ease of use of the program, the service and customer relations offered by the company, or some combination of these factors.

ALEKS[52]

As we noted earlier, ALEKS (Assessment and LEarning in Knowledge Spaces) is a Web-based, individualized learning assistant. Developed at the University of California by a team of software engineers and cognitive scientists, with support from the National Science Foundation, ALEKS is an artificial intelligence engine—an

[52] Our point of contact is Carolyn Plummer, Workforce Distance Learning Services.

adaptive form of computerized intelligence. ALEKS is capable of searching an enormous knowledge structure and ascertaining the knowledge state of the individual student, all the while interacting with its environment and adapting output to complex and changing circumstances.

ALEKS is based on theoretical work in Cognitive Psychology and Applied Mathematics in a field known as "Knowledge Space Theory" that was begun in the early 1980s by the Chairman and founder of ALEKS. It is a comprehensive Web-based, self-paced math curriculum that offers individualized assessments, exercises, explanations, feedback, and coaching for courses that range from basic math to advanced calculus.

When first logging on to ALEKS, a student enters the Assessment Module. ALEKS quickly assesses the student's current knowledge of the subject by asking a limited number of questions. For instance, the arithmetic assessment includes fifteen to twenty-five questions and takes about one-half hour to complete. ALEKS chooses each question on the basis of the student's answers to all the previous questions. Using these answers, ALEKS develops a detailed and comprehensive map of the student's mastery of the subject.

At the conclusion of the assessment, ALEKS determines the concepts that the student is ready to learn, based on that student's current knowledge state. These new concepts are shown to the student, who then initiates the next phase, the Learning Mode, by clicking on any highlighted phrase representing a concept in the list.

The focus of the learning mode is a sequence of problems to be solved by the student, representing a series of concepts to be mastered. The facilities offered by the learning mode are:

- Practice (that is, the problems themselves);
- Explanations of concepts and procedures;
- Dictionary of mathematical terms.

For example, a student working on a particular problem may request an explanation of that problem by clicking on the button marked "Explain."

After reading the explanation(s), the student may return to "Practice," where he or she will be presented with another problem exemplifying the item or concept just illustrated. If the student is successful in solving this problem, the system will usually offer two or three more instances of the same item to make sure the student has mastered the material.

In the text of problems and explanations, mathematical terms (for example:

"addition," "factor," and "square root") are highlighted. Clicking on any highlighted word or phrase will open the mathematical dictionary to a definition of the corresponding concept. The dictionary can also be used independently of the current problem to look up any term about which the student is curious.

Other features of the learning mode include:

- Feedback;
- Progress monitoring;
- Practice.

Whenever the student attempts to solve a problem in the learning mode, the system responds to the input by saying whether the answer is correct and, if it is incorrect, what the student's error might have been.

ALEKS follows the student's progress during each learning sequence and will, at times, offer advice. For example, if a student has read the explanation of a problem a couple of times but provides a number of incorrect responses, ALEKS may suggest that the student look up the definition of a certain word in the ALEKS online dictionary. ALEKS may also propose that the student temporarily abandon the problem at hand and work instead on a related problem. When a student has demonstrated mastery of a particular concept by solving a number of problems based on it, ALEKS encourages the student to proceed to a new concept.

NetTutor, a companion product for ALEKS, was developed by Link-Systems International. NetTutor provides comprehensive support services for ALEKS users working independently or in a learning lab situation. Live tutors are available to students for more than seventy hours per week for real-time assistance with all levels of mathematics, including basic and intermediate mathematics, algebra, applied algebra, linear algebra, geometry, trigonometry, calculus, and statistics. ALEKS users who need assistance after hours can send email messages for tutors to answer when on duty. Live tutoring occurs via an easy-to-use WorldWideWhiteboard technology that allows for fast, visually oriented content tutoring.

Many colleges have used ALEKS, including some of those selected for having promising practices, as have businesses and other entities. We report on one pilot and its evaluation particular here.

The New Jersey Health Care Employers District 1199J and the American Federation of State, County and Municipal Employees (AFSCME) Training & Development Fund recently piloted ALEKS/NetTutor. The pilot consisted of thirty-seven students in entry-level positions in hospitals and nursing homes (mostly Certified Nursing Assistants) in the Transition to Nursing Program. These students

were studying to become Licensed Practical Nurses. The pilot began on September 15, 2003.

Before the pilot, ALEKS/NetTutor went through a vigorous assessment by a team consisting of six people: four instructors and two full-time staff members. The team was directed to determine if ALEKS/NetTutor could be used in conjunction with the Fund's existing basic math classes.

After completing the ALEKS/NetTutor assessment and going through the program as extensively as possible, the team members were asked to review ALEKS with the intention of using ALEKS/NetTutor in conjunction with their basic math classes. The review team decided to implement ALEKS/NetTutor as a basic math tutorial for students to use as an additional math-learning tool.

Of the population involved in the pilot, thirty-three of the thirty-seven students have accessed basic math, five beginning algebra, and one intermediate algebra. A midterm evaluation of the program was conducted on site. Instructors and students were asked to respond to a separate questionnaire to gain insight into the efficacy of ALEKS/NetTutor, as it related to the Fund's goals.

The results from the instructor evaluation demonstrated that the instructors found ALEKS/NetTutor to be valuable for their students. When asked what they liked about the program, most of the instructors noted that they found the individualized course of study that resulted from the assessment to be a major plus for the program. Other positive features included the 24-hour access (some students accessed the program outside of the lab) and the quality and thoroughness of the explanations. One goal of the pilot by the Fund was to increase reading comprehension among the students; the explanation feature in ALEKS was instrumental in motivating students to read more.

When asked if they would recommend ALEKS/NetTutor for future classes, there was unanimous agreement among all four instructors that they would like to continue with the program and use it in future classes. In addition, the instructors found a strong correlation between the assessment results in ALEKS and the instructors' evaluation of the student based on observation, conversation, quizzes, and tests. However, one instructor noted that some students scored higher on certain topics in the ALEKS assessment than their level of mastery. Overall, the reaction to ALEKS/NetTutor for Fund students by instructors was very high.

The twenty students who responded to the survey also had positive feedback. Specifically, when probed to find out if ALEKS/NetTutor helped to increase the students' overall understanding of math, nearly all of the students stated that the program was helpful because of the detailed, clear, and easy-to-understand

explanations; the repeated practice questions; the way the program breaks down a problem into concise steps; and the opportunity to work at their own pace. An added benefit to working on ALEKS/NetTutor cited by students included an increase in proficiency on the computer (although most students responded that they felt they possessed adequate computer skills to use the program).

The early data from this pilot indicate that ALEKS/NetTutor is an effective learning tool for adult workers studying independently or in a more structured tutoring lab situation. However, this pilot indicates that the success of the product requires a reliable support system.

RxTechSchool[53]

Pharmacy Choice, Inc., developed RxTechSchool as an education Web site for pharmacy technicians. Pharmacy Choice is an application service provider and professional services company for the pharmacy and pharmaceutical industries. The Pharmacy Choice Web portal provides pharmacists, pharmacy technicians, students, and others in the industry with Web-based tools and information, including career services, drug information, and continuing education.

National Pharmacy Technician Certification is obtained by passing a comprehensive exam, an important goal for many pharmacy technicians because 70 percent of employers increase compensation to pharmacy technicians once they become nationally certified. In addition, while a nationwide shortage of pharmacists and a growing consumer demand for prescription medications have allowed pharmacy technicians the opportunity to play an increasingly important role in today's pharmacy industry, the increased opportunity has also required increased responsibility. This increased responsibility has made National Pharmacy Technician Certification an important issue for many industry employers and even to some state legislatures. The state of Texas, for example, now requires all people who work as pharmacy technicians to become nationally certified. The Pharmacy Technician Certification Board sets the standards for certification and administers the examination. Between 10 and 15 percent of the examination items require knowledge of algebra, and about 70,000 people sit for the exam each year.

RxTechSchool provides training to roughly 300 people per year in the math refresher course in preparation for the certification exam. The refresher course, “Online Math Calculations for Pharmacy Technicians,” was developed by the former president of the Pharmacy Technician Educators Council, Noah Reifman, because he was concerned that many technicians may not be able to pass the certification exam without additional education or training, specifically in algebra. Although the content for the course was first developed as a book, it has now been placed online in

[53] Our point of contact is Jasmine Pacheco, RxTechSchool.

a basic text format in which different portions of the book are hyperlinked to a main menu for reading. The course itself is strictly self-study, and students are given up to one year to complete the course. Each section has exercises that students must complete before moving on to the next section. Once a student completes a section of the course, he or she submits the exercises and then automatically receives the answers to the questions just submitted.

The course has a total of ten sections. For students who are thorough and consistent in their attempt to cover the material, it would require a minimum of eight weeks to complete. Since the course is self-paced, however, this time period can be much longer.

If students participate in the full pharmacy technician preparation course, they have access to a registered pharmacist to answer any questions as they move through the course. Those taking only the math portion, however, are on their own to find solutions to the problems.

Though not required, a simple scientific calculator is helpful for students when taking the course. However, the certification examination does not permit the use of a calculator.

The student population varies greatly in age, from eighteen to seventy. RxTechSchool serves many foreign pharmacists who were not educated in the United States. Because they are not able to be fully licensed as pharmacists, many opt for the technician certification. A large percentage of the participants are incumbent workers who have non-licensed positions in the pharmacy profession and are attempting to upgrade their pay and status within the pharmacy.

Adult Tech Prep Bridge[54]

Adult Tech Prep Bridge Programs prepare adults for employment as technicians and for postsecondary technical education in advanced technology fields. The programs are designed to provide the foundation for career-long learning, both on the job and in formal technical training. The program implemented at Henry Ford Community College in Detroit employed a conceptual framework intended to guide the development of bridge training programs in Chicago and elsewhere, and we describe that program here.

The framework for this bridge program was developed through a three-year project funded by the National Science Foundation's Advanced Technological Education program. The goal of the project, which was carried out by teams in

---

[54] Our points of contact are David Jenkins, University of Illinois at Chicago; Ray Prendergast, City Colleges of Chicago; Gary Saganski, Henry Ford Community

Chicago and Detroit, was to develop, pilot-test, and disseminate instructional materials for bridge training programs. The intent was to enrich understanding of the foundation skills needed for career-path employment in technical fields, and of instructional methods that are effective in enabling adults to master these skills.

Although the project focuses on training for advanced technological education and employment in manufacturing, the aim was to produce program materials and guidelines that are applicable to bridge training for other fields as well. The Chicago and Detroit project teams agreed that bridge training must consist not of a single program but of a series of programs, each providing preparation for successively higher levels of employment and education. The need for multiple bridge levels stems from the nature of the supply and demand for skilled labor in manufacturing and other advanced technology fields.

On the supply side, among the many adults who would seek employment as manufacturing technicians, there is considerable variation in the level of basic skills and "job readiness." People with few basic skills and many barriers to employment will need multiple levels of support, education, and training to advance over time to better paying jobs. On the demand side, jobs at different levels of pay and responsibility carry different sets of qualifications. In manufacturing and other advanced technology sectors, the gap in qualifications between low-wage, unskilled jobs and better-paying, more skilled jobs continues to widen.

The mathematics portion of the program that was implemented both in Chicago and in Detroit was developed first for the Chicago program at Instituto del Progreso Latino, which provides education programs for Latino adults and their families through literacy training, education classes, vocational programs, and family support services. One math class was developed that contained blueprint reading, metrology, and other topics that were closely related to a machine shop training course provided by Daley College (one of the colleges in the City Colleges of Chicago system). Students were required to pass the TABE with a score of 8.3 before being admitted to the program.

The intent of the math course was to teach arithmetic functions with whole numbers, decimals, and fractions. The decision early on was to use practical applications related to machine shop training to communicate such concepts as calculating tolerances off blueprints or measuring with micrometers and calipers. The course included some algebra and trigonometry, with such concepts as the Pythagorean theorem, statistical process control, or sines and cosines incorporated into shop problems.

It was determined that a workbook should be developed specifically for this population in order to tie in the shop applications since the developers could not

locate another text that made this connection adequately. Similar to the RxTechSchool case, the developers were keenly aware of the importance of the National Institute for Metalworking Skills (NIMS) standards and meeting those standards at the conclusion of the program.

Most students entering the program could not read a micrometer, nor were they proficient in performing arithmetic operations on decimals. At the conclusion, they could interpret blueprints and tolerances correctly and could read a micrometer and calipers. So the math portion of the program was relatively successful from a skills development point of view.

The number of students was limited to fifteen per class to enable interaction with the teacher during math laboratories involving the shop applications. Often the students were required to read and interpret real prints by performing calculations of tolerance limits or angles, for example. Very often a print will provide an angle specification that cannot be measured, so it is necessary to measure the complementary angle. Homework was sometimes assigned but not often done by students. Perhaps this is because all students were working at the time they took the course, but it was not an employer-paid program.

Students did not receive a grade for the math course. As a consequence, the course did not impose a demand structure on the students for achieving completion of the concepts. The program ran for sixteen weeks, and students received fifty-six contact hours in mathematics during this period.

Discussion

Our selection of training provided for businesses illustrates a number of themes that we have found in our research. First, the types of mathematics and extent of the curriculum provided are more fluid and less well defined than what is necessary to prepare students to pursue college-level mathematics. The content and extent of the training in these business examples are a function of both the skill set of the individual learner and the career choice or specific job requirements of the student or his or her employer. Perhaps this is why so much more self-paced instruction is used for business-specific training; adult learners can eliminate sections or courses that are not directly relevant to their immediate career goals. Community college students, by and large, are not given that option.

Second, support systems for adult learners involved in business-specific training are generally lacking, especially in contrast to those provided by the community colleges we described with promising practices. For example, none of these programs specifically address study skills or provide career counseling, on-site computer labs, or venues for collaborative group work.

Third, we note that good solid analysis of the effectiveness of programs specifically targeted toward business applications is scarce; we were not able to obtain basic information concerning the success rates of learners through any of these programs. Unfortunately, that means that we have no way to compare the success rate of students in these programs with those in community colleges—in terms of passing the course(s), progressing to higher-level mathematics, or improving their careers.

We conclude from this that there are few lessons learned, at this point, from the practices of businesses in providing basic math skills training to their employees or from other workforce enhancement programs. Yet this is an important line of research, especially in light of the fact that there is growing demand for workers with math skills. It is important to understand, for instance, which knowledge and skills are learned best, and by which types of learners, in the much shorter training pipeline provided by the business model versus the longer associate degree or certificate path.

Deleted: . I

Deleted: i

Deleted: whether the success rate of people through

Deleted: sufficiently addresses the needs of business, as well as the desire of adult learners who want to improve their career progression.

THE U.S. MILITARY

We turn now to our findings concerning developmental mathematics instruction in the military services. The services are unique in a number of ways, especially in terms of whom they recruit and how they train their workforces. As we will discuss, they are similar to businesses in that they rely heavily on colleges to provide various educational services to servicemembers, particularly education that they seek in their off duty hours. Other similarities include the fact that they do not have comprehensive data or analysis of the effectiveness of various strategies, especially for education programs that are offered on a voluntary basis. As a consequence, few measure of "success," especially related to the one we are using in this study, are collected by each service. Therefore, our discussion that follows is a documentation of what the services do in terms of developmental mathematics, rather than a highlight of selected successful strategies. As we will see though, there are some common themes shared in these practices with successful community colleges and promising practices used in businesses.

General Eligibility Requirements

All of the services have basic enlistment eligibility criteria that result in each workforce being unique in a number of attributes. Most significant for our purposes is the fact that recruits are screened based on age, moral background (e.g., arrest histories and prior drug use), medical conditions, mental ability, and education credentials. The latter is especially important; by law, no more than 10 percent of any service's total annual accessions[55] can be non-high-school-diploma graduates (NHSDGs). The reason for the cap is that there is a significant body of evidence showing that NHSDGs are much less likely than high school diploma graduates to complete their enlistment contracts. Also for the purpose of this cap, recruits with GEDs are considered in the NHSDG category because their attrition behavior is more similar to dropouts than it is to graduates.

Within the cap, each service is permitted to manage its own mix of recruits. While the Army and the Navy strive to cap their NHSDG accessions at 5 percent, during the very difficult recruiting period of the late 1990s, both services had to increase their caps to 10 percent. In recent years, they have decreased their caps steadily. The Marine Corps has consistently accessed 5 percent or fewer NHSDG accessions, and the Air Force typically accesses less than one percent NHSDGs, and almost all of these possess GEDs.

---

[55]The term "accession," as used by the military, is reserved for those who begin military active duty. This is a smaller number than those who are recruited, since the entire recruiting process has a number of phases. A certain proportion of recruits never attain active-duty status. To access is to successfully make that transition to active duty.

Armed Services Vocational Aptitude Battery

Another important screen for our purposes is the one the services use to assess mental ability, which they do with a test known as the Armed Services Vocational Aptitude Battery (ASVAB). The test consists of eight components, and ASVAB scores are standardized to a nationally representative sample of American youths (18- to 23-year-olds) who took the ASVAB in 1980,[56] with each test normalized[57] to have a mean of 50 and a standard deviation of 10.

The scores on various subtests are used to screen recruits for specific occupations, and a weighted average of four of the tests compose the Armed Forces Qualifications Test (AFQT), used for basic enlistment eligibility: Arithmetic Reasoning, Math Knowledge, Paragraph Comprehension and Word Knowledge. The AFQT is expressed as a percentile.

Congress has stipulated that the services cannot recruit people who score in the lowest 10 percentile of AFQT scores, and only 20 percent may be in the 10th through 30th percentile. Further, NHSDGs must score above the 30th percentile (Title 10, United States Code, Section 520). However, most of the services impose even higher standards. For instance, the Navy currently does not access anyone who scores below the 31st percentile on the AFQT.

Thus, all of the services do assess the basic skills competency of their recruits in the areas of reading, writing, and mathematics, and they establish certain criteria for admission. Beyond the screens for admission, however, the services also screen recruits for their military occupation, based on ASVAB scores. For instance, to enlist in one of the Navy's most technical programs, the Advanced Electronics/Computer Field (AECF), in addition to stricter screening criteria that pertain to citizenship, color perception, and moral background, the Navy imposes requirements in terms of math, electronics, and general science knowledge (U.S. Navy Recruiting Manual 2002). These thresholds have been established to ensure that the recruit will have a satisfactory chance of successfully completing the training, which takes as long as 18 months.

Because of these ASVAB requirements, the services typically do not recruit people who are significantly deficient in their math skills who also will require higher-level math to perform their job. Instead, those with inadequate math skills either are not recruited, or are chosen for occupations that do not require those skills.

Servicemembers who need minimal remediation in math may receive some as

---

[56] The services are in the process of renorming the ASVAB based on a sample from the late 1990s.

[57] related to a normal or bell-shaped curve distribution

part of their training, but this would typically involve only short courses of a few days in length. Instead, servicemembers with deficient math skills often pursue developmental mathematics education to enhance their own personal goals, such as to improve their ASVAB scores in order to requalify for another occupation, to earn a GED, or to pursue a college education. All of these pursuits would be under what the military terms Voluntary Education (VolEd). VolEd in the military consists of numerous programs, each leading to various education outcomes and each with a variety of financial support to the servicemember. In fiscal year (FY) 2004, Department of Defense (DoD) spent $607.3 million on all VolEd programs (U.S. Department of Defense 2005).

Basic Skills

The lowest level of VolEd consists of basic skills training—that which helps servicemembers (primarily enlisted personnel) master the reading, writing, and mathematics skills necessary to either do their job or accomplish their personal education goals. In FY04, 38,389 enlisted servicemembers, or 3.2 percent of the total, enrolled in noncredit basic skills courses:

- 19,072 in the Army;
- 13,547 in the Navy;
- 2,534 in the Marine Corps;
- 3,236 in the Air Force.

All of the services pay 100 percent of the cost of studies and testing that lead to a GED. In FY02, 26 soldiers, 62 sailors, 18 Marines, and no airmen received high school diplomas or GEDs while on active duty (U.S. Department of Defense 2004). As we noted previously, the Air Force rarely allows anyone to enlist who does not have either a high school diploma or a GED.

Postsecondary VolEd

For servicemembers who want to pursue postsecondary education, there are a number of avenues, and they vary by service. Tuition Assistance (TA), which is offered by all the services, provides 100 percent of the mandatory tuition and fees at accredited institutions of higher education, up to $250 per semester hour. All of the services except the Navy cap this assistance at $4,500 per year. The Navy limits funding to 12 semester hours per year (Military.com 2003).

The Army, Navy, and Marine Corps have a group of colleges that together compose the Servicemembers Opportunity Colleges (SOC), a consortium of approximately 1,700 colleges, which is cosponsored by the American Association of State Colleges and Universities (AASCU) and the AACC. Among other requirements, members of the consortium agree to accept credit awarded from other

members. This feature is an important consideration for servicemembers who move frequently and so may not be able to complete a degree at the institution that originally granted credit. The Air Force does not have a comparable consortium. Instead, it has the Community College of the Air Force, which serves a similar function.

Research Studies of Successful Strategies in the Military

We consulted with members of the Navy and the Army research staff, and conducted academic literature searches and a search in the Defense Technical Institute Center (DTIC) repository (DTIC 2003), but were not able to identify research that has been conducted concerning the effectiveness of the services' basic skills education in developmental mathematics. The only study that emerges on this topic in general is one that was conducted in the late 1990s by the Center for Naval Analyses (CNA) (Garcia 1998). The Navy wanted to conduct an analysis of the effectiveness of VolEd because so little was known about the returns to this program, including basic skills and postsecondary education.

Using an econometric technique that controls for self-selection bias inherent in a voluntary program, this study found that, relative to nonparticipants, participants in the VolEd program got promoted faster and farther, had fewer disciplinary problems, and had higher retention even after controlling for relevant factors, such as military specialty and demographics. Furthermore, the study calculated a return on investment (ROI) for various components of the program by comparing the implied reduction in recruiting and training costs from higher retention to the cost of the program. The ROI on the adult basic education component of the program was even higher than the ROI on more advanced skill components.

Absent other scientifically based studies of the effectiveness of VolEd in general, and developmental mathematics specifically, we modified the project's goal from identifying successful strategies in developmental mathematics in the services, to describing the most salient components of each of the services' developmental mathematics programs, and to gathering as much available relevant information from each branch as possible. We turn now to a description of these findings.

Individual service programs and survey results

We approached the head of voluntary education in each branch of the military to answer questions concerning basic mathematics skills courses offered to servicemembers in FY04. In some cases, we were referred to other contacts; in the case of the Air Force, we were told that the Air Force does not provide basic skills training because of its rigorous academic admission requirement (Sweizer 2004). We were also told by the Coast Guard that it does not offer the types of courses that we are concerned with in this study (Lis 2004).

Our questions included such topics as enrollments, pass rates, duration of instruction, selection criteria for each course, status of instructors (whether they were enlisted servicemembers, officers, college faculty, training vendors, and so on), overall content focus of each course, instructional modes, technology options, approaches to teaching and learning, types of outcomes evidenced by each program (such as faster promotion), other metrics available for servicemembers who enroll in the course (such as attrition from the course or from the service during the course or reenlistment rates), and instructor qualifications. We describe the results from each of the services below.

For reference, in terms of teaching and learning approaches, we asked the services to indicate the degree to which each of the following are used in developmental mathematics courses, using a scale of 1 to 5 (where 1=never, 2=rarely, 3=sometimes, 4=frequently, 5=almost always or always):

- High level of student-teacher interaction;
- High levels of peer interactive learning;
- Real-world problems;
- Independent research;
- Activities requiring students to collect or measure their own data for problems;
- Interdisciplinary activities;
- Activities requiring students to interpret their own results;
- Activities requiring students to present results to the class;
- Activities requiring students to apply concepts they've learned to situations with which they have no experience.

The survey also asked each service to indicate on a scale of 1 to 4 (1=not effective, 2=minimally effective, 3=moderately effective, 4=highly effective) the degree to which various outcomes were a consequence of servicemembers taking each of the developmental mathematics courses. The specific outcomes included:

- Servicemembers are able to advance faster;
- Servicemembers are prepared to pursue college-level math either as a part of official training or on a voluntary basis;
- Servicemembers who enroll have a reduced level of math anxiety when they complete the course;
- Servicemembers who enroll are able to requalify on the ASVAB.

The ability to requalify on the ASVAB is important to servicemembers primarily because it is these test scores that are used to determine whether they are qualified for various occupations. Changing occupations is desirable sometimes because of better promotion opportunities or special pays associated with various

occupations. And in the case of the Navy, the ability to requalify for other ratings has become increasingly important for sailors in overmanned ratings who wish to reenlist, but who are required to change ratings in order to do so. This is part of the Perform to Serve policy that began in March 2003.

The results of these surveys are summarized in the following three tables. Table 13 includes basic information pertaining to enrollments, pass rates, and basic pedagogical facts. Table 14 summarizes teaching and learning approaches, while table 15 summarizes the effectiveness of each program in achieving various outcomes.

Table 13: Basic parameters of military service programs

Service	Program	Enroll-ment	Requirements	Course length	Pass rate	Provider	Software	Instructional mode
Army	Self-paced, distance learning	2,585	≤ 495 on SAT ≤ 21 on ACT	4.5 hours	85.0	Pearson Digital Learning	Destina-tions NovaNet	Self-paced, distance learning with computers
Marine Corps	MASP	1250	Low ASVAB composite score Low TABE Referral by Commanding Officer	80 hours	94.1	Contractor		Instructor-led
Navy[1]	NCLC	3,500	None	22 hours	Unknown	Contractor	PLATO	Facilitated self-paced with computers
	Instructor-led Academic Skills	1,401	None	45 hours	Unknown	Contractor	N/A	Instructor-led and self-paced without computers
	NCPACE	3,908	None	45 hours	Unknown	Contractor	N/A	Instructor-led

[1] Navy enrollment numbers include sailors in developmental mathematics courses only.

Table 14: Teaching and learning approaches in military courses[1]

Service	Program	Student-teacher interaction	Peer inter-active learning	Real world prob-lems	Inde-pendent research	Collect own data	Inter-disciplin-ary activities	Interpret own results	Present results	Apply concepts to other situations
Army	Self-paced, Distance learning	2	2	3			3	2		4
Marine Corps	Instructor-led	4	3	3	2	3	3	3	3	3
Navy	NCLC	4	3	3	1	1	3	1	1	3
	Instructor-led Academic Skills	4	3	3	1	1	3	1	1	3
	NCPACE	5	5	3	1	1	3	1	1	3
	College courses on base[2]	5	3	3	1	1	1	3	3	3

[1] Response values are as follows: 1=never, 2=rarely, 3=sometimes, 4=frequently, 5=almost always or always.
[2] Value is the median value of all responses for all bases responding.

Table 15: Outcomes of military courses[1]

Service	Program	Advance Faster	Prepared for college-level math	Reduced level of anxiety	Requalify on ASVAB
Army	Self-paced, distance learning	4	4	4	
Marine Corps	Instructor-led	3	3	3	4
Navy	NCLC	Unknown	4	4	4
	Instructor-led Academic Skills	Unknown	4	4	4
	NCPACE	Unknown	4	4	4
	College courses on base	3	4	4	4

[1] Response values are as follows: 1=not effective, 2=minimally effective, 3=moderately effective, 4=highly effective.

We turn now to a discussion of the results from each of the services.

Army

The Army's program is called the Basic Skills Education Program (BSEP), designed to help soldiers master the functional reading, writing, and mathematical skills required of their jobs. In 1999, the Under Secretary of the Army directed that BSEP should be automated and fully deployed (Bilodeau 2003). The Army found in an evaluation of three commercial off-the-shelf (COTS) products[58] students performed as well on TABE posttests as soldiers who took traditional BSEP courses. As a consequence, Lifetime Library won a contract to provide the software on bases worldwide (Minn MATYC 2005).

BSEP is open only to soldiers who score below the 10th grade level on TABE, or whose General Technical (GT) scores are below 100 (U.S. Army 2003). GT scores are a weighted sum of the scores on the Paragraph Comprehension, Word Knowledge, and Arithmetic Reasoning ASVAB subtests. All services except the Navy standardize this composite score to have a mean of 100 and a standard deviation of 20.

According to Dian Stoskopf, the Army Chief, Education Division, the Army

[58] Lifetime Library, Passkey, and PLATO.

does not support course work relevant to what we are concerned with here (Stoskopf 2004). However, we were able to obtain information concerning a developmental mathematics program used by the Army for people in the Reserve Office Training Corps (ROTC). ROTC is a scholarship program used by all branches of the military, in which the military covers the cost of tuition, fees and textbooks and also provides a monthly allowance for candidates to attend a participating accredited four-year college or university. Upon graduation, the candidate is also awarded an officer commission.

The Army provides math skills remediation as part of a required program to all servicemembers in Cadet Command (college ROTC juniors and seniors). The Enhanced Skills Training Program (ESTP) is designed to improve cadets' skills in reading, writing, and mathematics, and all cadets who score less than 495 on the math subtest of the SAT, or less than 21 on the ACT math subtest, must participate in the math curriculum. Satisfactory SAT or ACT scores, or completion of the remediation program, are required for commission as an officer in the Army (Winters 2005).

In 2003, the ESTP mathematics program was modified to exclude math topics beyond basic algebra. Before then, topics included algebra, probability, geometry, and pre-calculus. Currently, the basic math skills courses include decimals, fractions, multiplication, division, percents, geometry, metrics, word problems, measurements, graphs, and charts. The courses are administered through distance learning using self-paced computers and Pearson Digital Learning's Destinations software. The individual course modules include Internet-based applications and other computer-assisted instruction.

Due to the self-paced, computer-assisted nature of the program, peer and student-teacher interactions are minimal. The software, however, is diagnostic and prescriptive. Destinations software can identify education gaps and assign appropriate lessons to fill the gaps quickly and efficiently. It allows servicemembers to work at their own pace and, according to the vendor, it is highly effective in (a) allowing cadets to advance faster, (b) preparing them to pursue college-level math, and (c) reducing their math anxiety. In 2003-2004, this program served approximately 2,585 cadets.

Marine Corps

The Marine Corps basic skills program is called Military Academic Skills Program (MASP). This is a four-week program targeted at Marines who score 99 or below on the GT and 10.2 or below on TABE[59]; there is an additional MASP

[59] TABE scores translate roughly to an equivalent grade level of subject matter mastery. In other words, a TABE score of 10.2 translates to the level of skills mastered by the second month of

preparatory course for those who score 8.5 or below on the TABE. Marines who have been referred by their commander also may enroll (U.S. Marine Corps 1998).

The content of the courses is equally divided among symbolism and algebra, geometry, functions, and probability and statistics (Taylor 2005), and courses are taught by academic institutions, using instructor-led lectures exclusively. Thus, the degree of student-teacher interactions is high. The instructors make frequent use of real-world problems, the collection and measuring of data, the interpretation of their results, class presentations, and the application of concepts learned to various situations.

In 2004, the MASP had an enrollment of 1,250 servicemembers with a 94-percent pass rate. According to the Head of the Marine Corps Lifelong Learning, in addition to a very high success rate, this program is moderately effective in enabling Marines to advance faster and to pursue college-level math. They have also been found to have less math anxiety upon completion of the program. Our contacts with the Marine Corps conclude that the program is even more effective in enabling Marines to requalify on the ASVAB, which, as we mentioned, is an important requirement for Marines who wish to change occupations.

Navy

All VolEd in the Navy comes under a program titled Navy College. Four different VolEd programs provide basic academic skills training that are covered in our review: Navy College Learning Centers (NCLCs), Instructor-Led Academic Skills, Navy College Program for Afloat College Education (NCPACE), and courses offered by two- and four-year colleges to servicemembers on naval bases worldwide. Jeffrey Cropsey, the Director of the Voluntary Education Department of the Naval Education and Training Professional Development and Technology Center (NETPDTC) provided responses for the first three of these programs, and directors of nineteen Navy College Offices from around the world completed a survey regarding college courses contracted on base.[60] Two bases (Commander, Fleet Activities Sasebo, and Naval Air Station Oceana) noted that they did not offer any on base developmental mathematics courses in FY04, and one (Naval Base Ventura

---

the 10th grade.

[60] The commands or bases follow: Commander, Fleet Activities Sasebo (Japan), Naval Air Facility Atsugi (Japan), Naval Station Rota (Spain) (responding for all of Europe), Naval Air Station Pensacola, Naval Station Ingleside, Naval Station Everett, Naval Sub Base Kings Bay, Naval Station Bremerton, Naval Base Coronado, Naval Base Ventura County, Naval Amphibious Base Little Creek, National Naval Medical Center Bethesda, Naval Station Pearl Harbor, Naval Station Norfolk, Naval Air Station Oceana, Naval Air Station Lemoore, Naval Construction Battalion Center Gulfport, Naval Air Station Brunswick, and Naval Support Activities Naples.

County) provided information for NCLCs only.

Both NCLCs and Instructor-Led Academic Skills are part of the Navy's Academic Skills program for sailors stationed on shore duty. The main difference in the two programs is that NCLCs offer self-paced courses in computer-interactive laboratories on naval bases, while Instructor-Led Academic Skills are conducted with civilian instructors in classrooms on the base or self-paced without computers.

The Navy has contracted to use PLATO's math fundamentals, pre-algebra, beginning algebra, and intermediate algebra exclusively in its NCLC program. Each course requires twenty-two hours on average. NCLC labs are open forty hours a week (U.S. Navy College 2004).

Attendance in Instructor-Led Academic Skills classes is recorded by the instructor, and all absences are reported to the Navy College Office. Classes are capped at fifteen students (U.S. Navy College 2004). NETPDTC indicated that these classes are held for a total of forty-five hours.

A third program is the Navy College Program for Afloat College Education, which offers both academic skills and college courses to sailors and Marines on sea duty. Contracted instructors from regionally accredited colleges and universities provide both types of courses, and Central Texas College administers the program. These courses are provided via technology and instructor-led classes aboard ship. However, all academic skills programs in NCPACE are instructor led (Navy College 2004). NETPDTC indicated that these courses convene an average of forty-five hours.

The fourth option covered in our survey is developmental math courses provided by accredited two- and four-year colleges that have been contracted by individual bases to provide courses on the base. The nature of these programs is comparable to those we surveyed from community colleges in general. In addition, survey responses from these programs supplement the information concerning longer-term effects of developmental math courses on the careers of enlisted servicemembers provided by NETPDTC, an outcome for which we have very little information for civilians in two-year colleges or in businesses.

Survey Results

Because the nature of the NCLC, Instructor-Led Academic Skills, and NCPACE courses are similar, and because their survey reports were consolidated, we discuss their findings first. We then turn to summarizing the results from the various college programs on naval bases.

NCLC, Instructor-Led Academic Skills, NCPACE

According to NETPDTC, approximately 18,500 servicemembers received basic math skills instruction through VolEd in FY04. About 9,000 of them received basic mathematics skills training via NCLC, Instructor-Led Academic Skills, or NCPACE. NETPDTC was not able to provide us with an estimate of the pass rate for servicemembers in these courses, or any other metric related to individual class outcomes (such as final exam scores), or specific career progression milestones (such as time to promote to the next rank). However, they did indicate that these courses are highly effective in preparing servicemembers to pursue college-level math, reducing the level of math anxiety of servicemembers, and enabling servicemembers to requalify on the ASVAB (see table 15).

There are no minimum test score criteria for sailors to take any of these courses, but, as we noted earlier, certain (unspecified) tests are used to determine appropriate placement. All instructors under these programs are required to possess at least a bachelor's degree and, in some cases, a current teaching certificate. The contractors provide any additional training.

In terms of teaching and learning approaches, the most often used, across all three programs, is a high level of student-teacher interaction (see table 14). Both NCLC and Instructor-Led Academic Skills use this frequently; it is almost always or always used in NCPACE. NCPACE also uses high levels of peer interactive learning almost always or always, compared with NCLC and Instructor-Led Academic Skills, which use it only occasionally. All three programs use real-world problems, interdisciplinary activities, and activities that require students to apply concepts they've learned to new situations only sometimes. Finally, none of the programs use independent research or activities requiring students to collect their own data, interpret their own results, or present results to the class.

Finally, they note that facilitation is critical to success for self-paced programs at this level, whether there is a computer component or not. Without facilitation, student dropout rates are significantly higher.

Developmental Math Offered by Colleges on Base

The responses to on-base college courses represent both two-and four-year colleges, with a majority (10 of 16) responding that they contract exclusively with a four-year college, four contract exclusively with a two-year college, and two contract with both. These responses represent a total of over 3,000 enrollments in

FY04, ranging from three to over 1,100 servicemembers enrolled yearly in each individual course.

Reported pass rates for these courses are problematic for a number of reasons. First, given the limited information provided in the response, it is difficult to determine whether the course is primarily an introductory or intermediate algebra course, or neither. Further, the pass rates were provided in some cases by the contracting institution, and sometimes from the Navy College Office on base. No standard was used for pass rate across all responses. As a result, in some cases they include grades of "D" or better, while for others the threshold is a "C" or better. Also, there is no consistency in whether servicemembers who withdraw from the course are included in the denominator of pass rates. Servicemembers may withdraw from a course for all of the reasons that civilian students do, but they are faced with additional challenges that are difficult to control for, such as deployments, attrition from the service, or reassignments, which are impossible to net out. Finally, some institutions could not differentiate the pass rates of servicemembers from that of civilian students enrolled in the same course.

With these caveats in mind, we note that the pass rates in general tend to be higher for servicemembers than for those we noted in community colleges with civilian students only. For instance, of the thirty different courses with reported pass rates, 80 percent report a pass rate of 90 percent or higher, and 93 percent had a pass rate of 80 percent or higher. In fact, one Navy College Office commented that the contracted college noted that the pass rate for sailors—about 80 percent in that case—is much higher than for nonservicemembers; the pass rate for the latter is only about 65 percent.

A number of plausible explanations for these exceptionally high pass rates are possible, such as the fact we noted previously that servicemembers differ from the civilian population in some important characteristics that affect academic achievement (for instance, there is a zero tolerance for drug use, the services screen recruits based on criminal record, there are minimum standards in terms of ability, and there are age limits to serving in the military). Further, servicemembers are enrolled in colleges that are contracted by the Navy, which is often a fairly desirable arrangement for the college. This may create greater incentives to ensure a higher pass rate. In any event, it is beyond the scope of this study to address the precise reasons why the reported pass rates of servicemembers in these courses are so high.

All but five of the surveys indicated that some placement test was required (the five either were blank or responded "don't know"). Of the remaining eleven, the most often cited placement test was ASSET (three surveys), ACCUPLACER

(two surveys), college placement test (two surveys), one each for TABE and COMPASS, and the remainder were either ambiguous or were college-specific placement tests.

The overwhelming delivery method of choice for all of these courses was instructor-led instruction (80 percent). The rest were either offered via distance learning (10 percent), independent study (3 percent), or as an option of either instructor-led or distance learning (8 percent). Only one course indicated that labs were used in conjunction with instruction. A very few courses also incorporated some self-paced student activities with computers.

Of the types of technology options used, two-thirds indicated that graphing calculators were used, and an additional 10 percent indicated that hand-held or algebraic function calculators were used. The next most prevalent technologies were Internet-based applications, which were used in over 40 percent of the courses; CAS, which were used in one-quarter; and computer-assisted instruction (CAI) and statistical software (including spreadsheets), which were each used in slightly more than 10 percent of all classes. Only one survey noted which specific technology was used, and that was PLATO math expeditions, and for one course only. These may be underestimates of actual use of these technologies because questions pertaining to the use of technology were either left blank or the respondents indicated they didn't know for almost 20 percent of all courses.

In table 14, we summarize the responses concerning the degree to which certain teaching and learning approaches are used and the outcomes of learning (both of which were defined previously). Not all institutions provided a response for each of these questions. In some cases, particularly in terms of outcomes evidenced, we presume that no response was an indication that they did not have enough information to answer the question. For others, particularly in the case of learning approaches, we cannot determine whether the lack of a response indicated lack of information, or was an indication that the technique was not used (in which case, the response should have been a 1). Since these omissions occurred most often in categories that appeared to be used the least often by those who did respond, we suspect the latter reason. Because we do not know for certain, rather than average the responses to these questions, which would overestimate the extent to which the particular approach is used or outcome evidenced, we report the median score for each category.

The responses concerning teaching and learning approaches are quite similar to the other Navy academic skills programs with only a few exceptions. In particular, interdisciplinary activities are used far less frequently in the on-base college courses than the other Navy programs, with half reporting that they

are never used. Conversely, while the other Navy courses never require students to interpret or present their own results, half of the colleges require students to interpret and present their results at least sometimes.

Similarly, the on-base college programs do not appear to differ significantly in terms of outcomes from those reported by the other Navy developmental math programs. Across the board, all Navy basic academic skills programs report that these programs are highly effective in preparing sailors for higher-level math courses, reducing anxiety, and improving sailors' ASVAB scores, which, we have noted, have a direct impact on many sailors' careers. In addition, half of the Navy College Offices that responded to the question concerning the ability of the course to help sailors advance faster said that these courses were moderately effective. Even so, few institutions noted that they had any other metrics available concerning performance in the course or in sailors' career progression after taking the course, including time to promotion to Petty Officer First Class (E5), and none provided actual metrics. In particular, of the respondents indicating they could assess various metrics, three had statistics concerning failures in the course, three had statistics concerning attrition, two had final exam scores, one had ASVAB requalification rates, and three had information concerning other voluntary education courses completed.

All of the institutions required at least a bachelor's degree of all instructors, some have an additional requirement that the major field must be in mathematics, and still others required a Master's degree.

Very few surveys indicated that training was made available to instructors. Of those that did, the most often cited training included topics in the subject matter, in pedagogy, and in technology (five to six institutions indicated one or more of these). One two-year institution noted that continuing education and professional development were available on request, as required in the professional development plan for faculty and staff. And one two-year institution noted that all new instructors receive orientation in objective methods, standards, and available resources.

Discussion

None of the services have conducted studies concerning the most effective strategies for basic skills instruction in mathematics, nor do they have good data on the success of the programs in general. Even if they did, as we noted, the services provide this type of instruction to a unique student body in terms of the types of screening required of all new recruits, as well as the special challenges servicemembers face in pursuing their education goals in their off-duty time.

We observe, however, that most of these VolEd programs share several strategies with the exemplary colleges chosen for this study. In particular, most of these courses are instructor led, provide a high level of student-teacher interaction and a moderate level of peer interactive learning, and incorporate real-world and interdisciplinary problems—strategies we deduce to be effective in community colleges more generally. Further, comments provided by personnel involved in teaching these courses concur with our previous findings, particularly that (a) students require different approaches to explain the material (b) the dropout rate is higher for those in self-paced and distance learning courses, and some facilitation is necessary to reduce attrition from courses of the latter type, and (c) many students are able to bypass the developmental course altogether if they are adequately prepared for the placement test.

CONCLUSIONS

This research has included an exhaustive review of the literature, surveys of current practices, and the identification of some of the most successful developmental mathematics programs in community colleges in the nation. We have also documented some of the practices employed by businesses and the military in providing basic math skills instructions to their workforces. Salient themes emerged, particularly in our work pertaining to postsecondary institutions, that allowed us to make a number of recommendations of particular strategies to enhance the success of developmental math students in postsecondary institutions.

But more could—and should—be done to promote our understanding of whether, in fact, these strategies are beneficial to students (especially when we control for confounding factors) and whether these benefits accrue equally across all students, regardless of age, gender, education credentials, native language, socioeconomic conditions, and so on. At the very least, community colleges need to be able to collect better data and need to be able to access a variety of student outcomes fairly easily. At the most fundamental level, this means recording basic demographic information about students enrolled in developmental math classes, such as those we noted. An additional step would be to require all students to take tests similar to the Noel-Levitz retention survey to measure certain attitudes and perceptions. And, at the very least, student satisfaction surveys that include questions about which strategies worked best for them and which were the least effective and that also collect basic demographic information could add valuable insight. To be most effective, however, these surveys need to be administered to students who withdraw, as well as to those who persist to the end of class, regardless of whether they pass.

In the absence of randomized controlled trial experiments, this type of information could then be used in multivariate analyses to increase our understanding of whether certain approaches are associated with greater success in all developmental math courses. Controlling for such factors as demographic characteristics and attitudes of the students will help identify which strategies help which students and under what circumstances. Simply adopting numerous strategies, adding as many support systems as possible, and requiring them of all students is not necessarily effective in terms of cost or education—to either the institution or the student.

APPENDIX A: TEXTBOOKS CITED IN INTERNET SEARCH

In table A-1, we include the title, author, publisher, and whether the text was cited as either being used in an introductory, intermediate, or combined algebra course, for all of the texts cited in the syllabi we searched online, as described in the text. If more than one text was used, we only include the first one. While some syllabi may state an older edition, we note the most current edition.

Table A-1: Textbooks cited in Internet sampling of community college algebra courses

Title	Author	Publisher	Type of course	Number of Colleges
Elementary and Intermediate Algebra, 2nd edition	Allen Angel	Prentice Hall	Intermediate	1
Beginning Algebra with Applications, 6th edition	Richard Aufmann, Vernon Barker, Joanne Lockwood	Houghton Mifflin	Introductory	2
Intermediate Algebra with Applications, 6th edition	Richard Aufmann, Vernon Barker, Joanne Lockwood	Houghton Mifflin	Intermediate	4
Introductory Algebra, An Applied Approach, 6th edition	Richard Aufmann, Vernon Barker, Joanne Lockwood	Houghton Mifflin	Introductory	1
Essential Geometry	Harry Baldwin	McGraw-Hill	Geometry	1
Elementary Algebra: Concepts and Applications, 6th edition	Marvin Bittinger, David Ellenbogen	Addison-Wesley	Introductory	2
Elementary and Intermediate Algebra: Graphs, & Models	Marvin Bittinger, David Ellenbogen, Barbara Johnson	Addison-Wesley	Introductory, Intermediate	1
Elementary and Intermediate Algebra Concepts and Applications: A	Marvin Bittinger, David Ellenbogen, Barbara Johnson	Addison-Wesley	Introductory, Intermediate	2

Combined Approach, 3rd edition				
Intermediate Algebra: Concepts and Applications, 6th edition	Marvin Bittinger, David Ellenbogen	Addison-Wesley	Intermediate	3
Introductory Algebra, 9th edition	Marvin Bittinger	Addison-Wesley	Introductory	2
Intermediate Algebra: Graphs & Models, 2nd edition	Marvin Bittinger, David Ellenbogen, Barbara Johnson	Addison-Wesley	Intermediate	1
Introductory Algebra for College Students, 3rd edition	Robert Blitzer	Prentice Hall	Introductory	1
Intermediate Algebra for College Students, 3rd edition	Robert Blitzer	Prentice Hall	Intermediate	1
Elementary Algebra, 5th edition	Mark Dugopolski	McGraw-Hill	Introductory	1
Intermediate Algebra, 5th edition	Mark Dugopolski	McGraw-Hill	Intermediate	1
Intermediate Algebra, 7th edition	R. David Gustafson, Peter Frisk	Thompson-Brooks/Cole	Intermediate	1
Elementary and Intermediate Algebra, 2nd edition	Elaine Hubbard, Ronald Robinson	Houghton Mifflin	Introductory, Intermediate	1
Intermediate Algebra: A Journey by Discovery of Curve-Fitting	Jay Lehmann	Prentice Hall	Combined	1
Beginning Algebra, 9th edition	Margaret Lial, John Hornsby, Terry McGinnis	Addison-Wesley	Introductory	2
Beginning and Intermediate Algebra, 3rd edition	Margaret Lial, John Hornsby, Terry McGinnis	Addison-Wesley	Introductory, Intermediate	2
Intermediate Algebra, 9th edition	Margaret Lial, John Hornsby, Terry McGinnis	Addison-Wesley	Intermediate	2
Essentials of	Margaret Lial,	Addison-	Geometry	1

Geometry for College Students, 2nd edition	Barbara Brown, Arnold Stephenson, L. Murphy Johnson	Wesley		
Algebra: A Combined Approach, 2nd edition	K. Elayn Martin-Gay	Prentice Hall	Introductory, Intermediate	1
Beginning Algebra, 3rd edition	K. Elayn Martin-Gay	Prentice Hall	Introductory	1
Intermediate Algebra, 4th edition	K. Elayn Martin-Gay	Prentice Hall	Intermediate	1
Intermediate Algebra: A Graphing Approach, 3rd edition	K. Elayn Martin-Gay, Margaret Greene	Prentice Hall	Intermediate	1
Beginning Algebra, 6th edition	Charles McKeague	Thomson Brooks/Cole	Introductory	1
Elementary Algebra, 7th edition	Charles McKeague	Thomson Brooks/Cole	Introductory	1
Developing Skills in Algebra: A Lecture Worktext, 2nd edition	J. Louis Nanney, John Cable	Hawkes Learning Systems	Intermediate	1
Intermediate Algebra Through Modeling and Visualization	Gary Rockswold	Addison-Wesley	Introductory, Intermediate	2
Experiencing Introductory and Intermediate Algebra, 2nd edition	Joanne Thomasson, Robert Pesut	Prentice Hall	Introductory, Intermediate	1
Beginning Algebra, 5th edition	John Tobey, Jeffrey Slater	Prentice Hall	Introductory	1
Intermediate Algebra, 2nd edition	Alan Tussy, R. David Gustafson	Thomson Brooks/Cole	Intermediate	1
Elementary Algebra With Applications, 4th edition	Terry Wesner, Harry Nustad	Wm. C. Brown	Introductory	1

APPENDIX B: CCSSE SURVEY RESULTS

Table B-1 contains the responses to survey items that we selected from the CCSSE 2003-2004 survey (with the level of the response noted).

Table B-1: CCSSE survey responses

	Percentage Responding Nontraditional Age Students		Traditional Age Students	
Question	Develop-mental	Nondevelop-mental	Develop-mental	Nondevelop-mental
How much has your experience at this college contributed to your knowledge, skills, and personal development in solving numerical problems? (quite a bit + very much)	63.6	46.4	58.3	45.5
How much has your experience at this college contributed to your knowledge, skills, and personal development in thinking critically and analytically? (quite a bit + very much)	73.6	63.7	67.5	58.4
How much has your experience at this college contributed to your knowledge, skills, and personal development in developing clearer career goals? (quite a bit + very much)	63.3	51.6	58.9	46.9
Have you done a developmental/remedial reading course while attending this college?	29.3	0	36.2	0
Do you plan to take a developmental/remedial reading course while attending this college?	18.7	0	18.0	0
Have you taken a developmental/remedial writing course while attending this college?	34.7	0	39.4	0
Do you plan to take a developmental/remedial writing course while attending this college?	25.2	0	23.1	0
Have you taken a developmental/remedial math course while attending this college?	58.1	0	60.2	0
Do you plan to take a developmental/remedial math course while attending this college?	33.5	0	28.3	0
Have you done, are you taking, or do you plan to take a study skills course while attending this college?	50.5	14.9	49.5	18.3

Have you participated, are you participating, or do you plan to participate in an organized learning community while attending this college?	37.2	18.3	35.1	17.3
How important are academic advising/planning services to you? (very)	70.7	58.9	63.2	53.6
How important arepeer or other tutoring services to you? (very)	49.3	34.5	40.7	30.5
How important are skill lab (writing, math, etc.) services to you? (very)	58.8	37.7	50.0	33.3
How important are computer lab services to you? (very)	64.7	55.1	62.5	55.2
How important are child care services to you? (very)	36.7	28.4	28.4	22.1
How likely is it that working full-time would force you to withdraw from class or from this college? (very)	24.9	21.5	19.6	16.0
How likely is it that caring for dependents would force you to withdraw from class or from this college? (very)	17.9	14.6	11.2	8.2
How likely is it that being academically unprepared would force you to withdraw from class or from this college? (very)	7.5	5.1	8.9	6.0
How likely is it that lack of finances would force you to withdraw from class or from this college? (very)	35.5	29.4	25.4	21.0
How likely is it that transfer to a four-year college would force you to withdraw from class or from this college? (very)	25.8	29.0	39.8	47.3
Is the goal of completing a certificate program a primary goal in attending this college?	37.0	35.3	34.7	25.8
Is the goal of obtaining an associate degree a primary goal in attending this college?	70.8	58.0	62.6	52.8
Is the goal of transferring to a four-year college or university a primary goal in attending this college?	44.8	43.9	68.3	70.0
Are grants and scholarships major sources for you to pay tuition at this college?	44.9	33.2	36.9	35.3

Is public assistance a major source for you to pay tuition at this college?	10.4	6.8	7.2	4.9
Percent responding that they most frequently take courses in the evening.	35.0	40.5	14.2	15.4
Percent responding that they have children who live with them.	54.7	48.0	13.1	9.7
Percent responding that English is their native language.	83.0	92.2	86.2	92.6
Percent responding that a high school diploma or GED is highest degree earned	72.2	61.0	94.1	91.9
Percent responding "none" is highest academic credential earned.	1.8	1.3	2.6	4.7
Is a vocational/technical certificate your highest academic credential?	17.9	15.2	2.4	2.3
Sample Size	17,192	13,951	22,643	18,175

[1] Sample sizes vary by question; we include the sample size for the last question in the table.

APPENDIX C: SUMMARY OF EXEMPLARY COLLEGE PROGRAMS

The following six tables summarize basic parameters of the exemplary programs chosen for our study. In table C-1, we summarize information pertaining to the developmental math level, up to and including intermediate algebra; the department that has responsibility for these courses; whether math is required of students pursuing an associate degree; the exit policy to transition out of developmental math; whether class limits exist for these developmental courses, and the various functions that counseling serves for developmental math students.

Table C-1: Overview of developmental math programs in selected colleges

College	Courses	Department	Math require-ment	Placement policy	Exit policy	Class limits	Coun-seling
American River College	-Overcoming Math Anxiety -Computational Arithmetic -Pre-Algebra -Elementary Algebra -Elementary Geometry -Intermediate Algebra	Math Department	Yes - varies	Informed Self-Placement	C or better	Maximum 36	None
Chandler-Gilbert Community College	-Numerical Skills -Elementary Algebra -Intermediate Algebra -Mathematical Concepts	Math Department	Yes -varies	Mandatory: ASSET	Elementary Algebra and Intermediate Algebra- Score at least 60% on common final	Maximum 28	B, D

College	Courses	Department	Math require-ment	Placement policy	Exit policy	Class limits	Coun-seling
Community College of Denver	Developmental -Fundamentals of Mathematics -Pre-Algebra -Introductory Algebra Nondevelopmental -Survey of Algebra	Center for Educational Advancement Math Department	Yes - varies	Mandatory: ACCUPLACER	C or better	Maximum 30	A, B, C, D, E, F
De Anza College	-Elementary Algebra -Intermediate Algebra -Elementary Statistics/Probability	Math Department	Yes – Intermediate Algebra required for A.A. degree	Mandatory: DTMS	Passing grade	Maximum 40	A, B, C, D, E, F

College	Courses	Department	Math requirement	Placement policy	Exit policy	Class limits	Counseling
Green River Community College	-Elementary Algebra -Intermediate Algebra	Math Department	Yes, any 100-level math or logic course	Mandatory: Compass	2.5 to go from Introductory to Intermediate Algebra (and all courses below) 2.0 to go from Intermediate to 100-level math	33	A, C, E, F
Miami Dade College	**Developmental** -College Preparatory Arithmetic -College Preparatory Algebra -College Preparatory Math **Transition Course** -Intermediate Algebra	Math Department	Yes - varies	Mandatory: SAT or ACT accepted; else ACCUPLACER	S or better in college preparatory classes, "C" or better in intermediate algebra	Preparatory: 32 Transition; 32-40	A

College	Courses	Department	Math require-ment	Placement policy	Exit policy	Class limits	Coun-seling
Mt. San Antonio College	-Elementary Algebra -Intermediate Algebra	Math Department	Yes - varies	Mandatory: In-house test for Elementary Algebra, MDTP 2 for Intermediate Algebra	Pass courses	36	A, B, C, E
Northwest Vista College	-Basic Mathematics -Introduction to Algebra and Geometry -Elementary Algebra -Intermediate Algebra	Academic Foundations Cluster	College Algebra satisfies most major degree plans	Mandatory: SAT or ACT accepted; else ACCUPLACER	"C" or better	None. Average size is 21	A, B, C, F
Onondaga Community College	-Pre-Algebra -Beg. Algebra -Interm. Algebra	Math Department	Yes - varies	Mandatory: adapted MAA tests	Pass courses	15-18	A, B, C, D, F

College	Courses	Department	Math require-ment	Placement policy	Exit policy	Class limits	Coun-seling
Zane State College	Developmental -Basic Computation -PreAlgebra -Pre-Business Math Nondevelopmental -Intro to Algebra -Algebra -Algebra and Trig I	Developmental Mathematics	Yes - varies	Mandatory except for transfer students: ACCUPLACER	60% in Algebra courses. Recommends at least 70% to progress to next higher course.	Developmental: 20, Algebra: 32	A, B, C, D, E, F

[1] Counseling responses: A=Counseling provides assessment for entering students to help place them in the appropriate developmental math course. B=Students receive counseling about what their assessment scores indicate regarding their strengths and weaknesses in mathematics. C=As part of the counseling portion of the developmental program, students receive orientation that assists them in planning their education. D=Students consistently receive follow-up counseling as they progress through their education program. E=Students receive career guidance within their first semester. F=The faculty member notifies counselors if a student is having difficulty in class.

Table C-2: Lab and tutoring policies in selected colleges

College	Lab Hours	Software	Tutoring Eligibility	Limits	Cost	Staffing	Hours
American River College	Mon-Thurs: 8 a.m. to 9:30 p.m. --Fri: 8 a.m. to 4:30 p.m. --Sat: 9 a.m. to 3 p.m.	-Quant -Math XL	All students	None	Free	Peer Professional	Mon-Thurs: 8 a.m. to 8 p.m., Fridays 8 a.m. to 2 p.m., Sat 11 a.m. to 2 p.m.
Chandler-Gilbert Community College	Mon–Thurs: 8– a.m. to 9 p.m. Fri: 8– a.m. to 3 p.m. Sat-Sun: 1– p.m. to 12 a.m.	Yes	All students	30-40 minutes per session	Free	Peer Professional	Mon-Thurs 8– a.m. to 9 p.m. Fri: 8– a.m. to 3 p.m. Sat-Sun: 1– p.m. to 12 a.m.
Community College of Denver	Mon-Thur: 9 a.m. to 7 p.m Fri, Sat: 10 a.m. to 2 p.m.	MyMathLab	Enrolled in math class	None	Free	Peer, pro-fessional	Mon-Thur: 9 a.m. to 7 p.m. Fri, Sat: 10 a.m. to 2 p.m.
De Anza College	Mon- Thurs: 8 a.m. to 8 p.m. Friday: 8 a.m. to 1 p.m.	Varies	Recommen-dation of professor, enrollment in develop-mental math	1 hour/wk of scheduled tutoring; unlimited drop in	Free	Peer	During class time; Mon- Thurs: 8.a.m. to 8 p.m. Friday: 8 a.m. to 1 p.m.

College	Lab Hours	Software	Tutoring Eligibility	Limits	Cost	Staffing	Hours
Green River Community College	Mon-Thurs: 7 a.m. to 7 p.m. Fri: 7 a.m. to 4 p.m.	Maple, PLATO, Geometer's Sketchpad, Minitab, Graphical Analysis, algebra tutorials	All	None	Free	Peer	Same as lab
Miami Dade College	Mon-Thurs: 7:30 a.m. to 9 p.m. Fri: 7:30 a.m. to 4 p.m. Sat: 8 a.m. to 4 p.m.	Numerous	Enrolled in math class	None	Each student pays $10 per math class to cover costs	Peer, professional	Mon-Thurs: 7:30 a.m. to 9 p.m. Fri: 7:30 a.m. to 4 p.m. Sat: 8 a.m. to 4 p.m.
Mt. San Antonio College	Mon-Thurs: 8 a.m. to –9 p.m. Fri: 8 a.m. to 5 p.m. Sat: 8 a.m. to 3 p.m.	Drill programs and math manipula-tion software	All	None	Free	Peer, professional	Same as lab

College	Lab Hours	Software	Tutoring Eligibility	Limits	Cost	Staffing	Hours
Northwest Vista College	Mon-Thurs:7 a.m. to 9 p.m. Fri: 8 a.m. to 8 p.m. Sat: 8:30 a.m. to 4:30 p.m.	None	All students	None	Free	Professional	Mon-Thurs:7 a.m. to 9 p.m. Fri: 8 a.m. to 8 p.m. Sat: 8:30 a.m. to 4:30 p.m.
Onondaga Community College	Daily: 8 a.m. to 4:30 p.m. Late afternoon and evening hours	MyMathLab Course COMPASS Plug-ins	Enrolled in math class	3 half-hour appoint-ments each week plus unlimited walk-in. Walks-ins are 15-minute sessions	Free	Peer, professional	Daily: 8:30 a.m. to 4:30 p.m.. Late afternoon and evening hours

College	Lab Hours	Software	Tutoring Eligibility	Limits	Cost	Staffing	Hours
Zane State College	Mon–Thurs: 8 a.m. to 7 p.m. Fri: 8 a.m. to 5 p.m.	Math Cue Solution Solution Finder, Math Cue Tutorial, Math Cue Practice Math Pro 5 MyMathLab	All students	2 hours per week	Free	Peer, professional	Mon-Fri: 8 a.m. to 5 p.m.

In table C-3, we provide the following information for Introductory and Intermediate Algebra courses: how long the course meets either each week or for the entire term; how many credits the course confers and whether it is college-level credit; whether labs are a required component of the course; the various instructional modes offered for the course; and any grading policies governing the course.

Table C-3: Pedagogical approach in selected colleges

College	Course	Convening	Credit/ Type	Lab	Instruction	Grading
American River College	Elementary Algebra and Introductory Algebra	90 hours per semester	5/non-transfer	No	Lecture Online/lecture Online	Up to instructor
Chandler-Gilbert Community College	Elementary Algebra	3.5 hours/week	4/non-transfer	Yes	Lecture	Up to instructor
	Intermediate Algebra	3.5 hours/week	3/trans-fer-level	No	Lecture	Up to instructor

College	Course	Convening	Credit/ Type	Lab	Instruction	Grading
Community College of Denver	Introductory Algebra	5 hours/week	4/non-transfer	In some classes	1. Lecture and lab 2. Learning communities with lab 3. Online 4. Branch campus	Department exams, weights up to instructor
	Survey of Algebra	5 hours/week	4/non-transfer	In some classes	1. Lecture 2. Learning Community with lab 3. Online 4. Accelerated online	Recommends 15-20% for division cumulative final, < 5% extra credit, and if a take-home mid-term is given, 2 other exams must be given in class.
De Anza College	Elementary Algebra/ Intermediate Algebra	5 hours/week or 10 hours/week in MPS	Degree appli-cable	Yes	Lecture, computer aided, lecture/collaborative/group work, and online (not MPS)	Must earn C or better grade

College	Course	Convening	Credit/ Type	Lab	Instruction	Grading
Green River Community College	Elementary and Intermediate Algebra	5 hours/week	5/non-transfer	No	1. Lecture 2. Online Computer assisted 3. Supple-mental independent study	Up to instructor
Miami Dade College	College Preparatory Algebra	6 hours/week	4/non-credit	Yes	Combined lecture/collab-orative study sessions/lab	Must complete 16 hours in Math Lab AND earn at least 70% in study sessions AND earn at least 60% on College Preparatory Exit Test, AND earn at least 70% total possible points.
	Intermediate Algebra	3 hours/week	3/non-degree	No	Lecture	Earn at least 60% on final exam AND at least 70% of total possible points.

College	Course	Convening	Credit/ Type	Lab	Instruction	Grading
Mt. San Antonio College	Math 51 Elementary Algebra	4 hours/week	4/non-transfer	No	Lecture	Recommends 85% weight on exams and quizzes, including final, 15% on homework, group work, etc. Final is at least 25% but no more than 50% of the course grade.
	Intermediate Algebra	4 hours/week	5/non-transfer	No	Lecture	Same as Elementary Algebra
	Accelerated Elementary and Intermediate Algebra	8 hours/week	9/non-trasnfer	No	Lecture	Same as Elementary Algebra
Northwest Vista College	Elementary Algebra, Introduction to Algebra and Geometry, Intermediate Algebra	150 minutes/ week plus 60 minutes/week required lab	4/insti-tutional credit only	Yes	-Instructor led with collaborative learning -Online	Up to individual instructor

College	Course	Convening	Credit/ Type	Lab	Instruction	Grading
Onondaga Community College	Beginning Algebra	150 minutes/ week	3/for financial aid only	No	Lecture	Must score 80% on all quizzes and exams, may retake tests until 80% is achieved.
	Beginning Algebra with Applications	200 minutes/ week Online students expect 8-10 hours/week	4/for financial aid only		Lecture and online	
	Intermediate Algebra with Applications	200 minutes/ week Online students expect 8-10 hours/week	4/for financial aid only	No	Lecture and online	
Zane State College	Introduction to Algebra	220 minutes/ week	4/non-transfer	No	Lecture and hybrid online	80% on all tests in Developmental math. 60% final grade
	Algebra	220 minutes/ week	4/non-transfer	No	Lecture and hybrid online	60% final grade
	Algebra and Trigonometry I	220 minutes/ week	4/non-transfer	No	Lecture	60% final grade

Table C-4: Algebra textbooks, software, and calculators used in selected colleges

College	Course	Textbook	Publisher	Software	Calculator policy	Calculator Type
American River College	Beginning Algebra	1. Beginning Algebra Lial 9th edition 2. Introductory Algebra Bittinger 9th edition 3. Beginning & Intermediate Algebra Martin-Gay	Pearson	Quant-Online sections MathXL-Lecture and Lecture/online sections	Allowed in some courses	Scientific
	Intermediate Algebra	1. Intermediate Algebra Lial 9th edition 2. Beginning & Intermediate Algebra Martin-Gay 3rd edition 3. Intermediate Algebra Hubbard/Robinson 2nd edition	Pearson Houghton Mifflin	Quant-Online sections MathXL-Lecture and Lecture/online sections	Up to instructor	Up to instructor

College	Course	Textbook	Publisher	Software	Calculator policy	Calculator Type
Chandler-Gilbert Community College	All	A. Tussy and R. Gustafson. *Elementary and Intermediate Algebra,* 2nd edition	Brooks/Cole		Required	TI 83 or TI 83 PLUS
Community College of Denver	Introductory Algebra	Margaret Lial, John Hornsby. *Beginning Algebra,* 6th edition (customized for CCD)	Addison-Wesley	MyMathLab	Recommended	Scientific
	Survey of Algebra	Margaret Lial. Intermediate Algebra, 9th edition	Addison-Wesley	MathXL	Recommended	Scientific
De Anza College	Elementary Algebra	Alice Kaseberg. *Introductory Algebra: A Just-in-Time Approach* Consortium For Foundation Mathematics. *Mathematics in Action*	Brooks/Cole Addison-Wesley	Varies by instructor	Varies by instructor	Scientific or Graphing

College	Course	Textbook	Publisher	Software	Calculator policy	Calculator Type
	Intermediate Algebra	Alice Kaseberg. *Intermediate Algebra: A Just-in-Time Approach* Consortium For Foundation Mathematics. *Mathematics in Action*	Brooks/Cole Addison-Wesley	Varies by instructor	Varies by instructor	Scientific or Graphing
Green River Community College	Introductory Algebra	A. Kaseberg. *Introductory Algebra*, 3rd edition	Brooks/Cole	Academic Systems for AS sections only	Required	Any graphing
	Intermediate Algebra	A. Kaseberg. *Intermediate Algebra*, 3rd edition	Brooks/Cole	Academic Systems for AS sections only	Required	Any graphing

College	Course	Textbook	Publisher	Software	Calculator policy	Calculator Type
Miami Dade College	College Preparatory Algebra AND Intermediate Algebra	K. Elayn Martin-Gay. *Algebra: A Combined Approach,* 2nd edition	Prentice-Hall	MyMathLab	Not used in College Preparatory Algebra class nor on exams. Used sparingly in study sessions. Up to the instructor in Intermediate Algebra	Varies with instructor
Mt. San Antonio College	Elementary Algebra	M. Lial, J. Hornsby, T. McGinnis. *Beginning Algebra,* 9th edition	Addison-Wesley	None	Determined by instructor.	Determined by instructor.
	Intermediate Algebra	R. Blitzer. *Intermediate Algebra,* 3rd edition	Prentice Hall	None	Determined by instructor.	Determined by instructor.
Northwest Vista College	All Algebra	K. Elayn Martin-Gay. Beginning and Intermediate Algebra, 3rd edition	Prentice-Hall	None	Not used except as a visual aid to topics in graphing	

College	Course	Textbook	Publisher	Software	Calculator policy	Calculator Type
Onondaga Community College	Beginning Algebra/ Beginning Algebra with Applications	M. Bittinger. *Introductory Algebra*, 9th edition	Addison-Wesley	MyMathLab	Allowed. Some instructors do not allow them on first test.	Any
	Intermediate Algebra with Applications	M. Bittinger. *Intermediate Algebra*, 9th edition	Addison-Wesley	MyMathLab	Allowed	Any
Zane State College	Introduction to Algebra	C. McKeague. Beginning Algebra, A Text/Workbook, 6th edition	Brooks/Cole	CD comes with text, and BCA tutorial	Required	Scientific
	Algebra	C. McKeague. Intermediate Algebra, A Text/Workbook, 6th edition	Brooks/Cole	CD comes with text, and BCA tutorial	Required	Scientific
	Algebra and Trigonometry I	A. Washington. Basic Technical Mathematics with Calculus, 7th edition	Addison-Wesley	MyMathLab	Required	TI-83 Plus

The following table summarizes two basic characteristics of faculty teaching Introductory and Intermediate Algebra: the percentage of all faculty teaching the course(s) who are full-time and the percentage possessing postgraduate degrees.

Table C-5: Percentages of faculty who are full-time and possess postgraduate degrees in selected colleges

College	Course	% Full-time	% With Postgraduate Degree
American River College	Elementary Algebra	65	0
	Intermediate Algebra	50	8
Chandler-Gilbert Community College	Elementary Algebra	13	7
	Intermediate Algebra	44	19
Community College of Denver	Introductory Algebra	12	69
	Survey of Algebra	18	88
De Anza College	Elementary Algebra, Intermediate Algebra and Introductory Statistics/Probability	42	97
Green River Community College	Introductory Algebra	45	91
	Intermediate Algebra	50	100
Miami Dade College	College Preparatory Algebra	0	N/A
	Intermediate Algebra	17	100
Mt. San Antonio College	All algebra courses	62	100
Northwest Vista College	Introduction to Algebra	53	53
	Intermediate Algebra	57	50
Onondaga Community College	Introductory Algebra	21	86
	Intermediate Algebra	41	100
Zane State College	All algebra courses	40	100

Table C-6: Metrics of interest in selected colleges

College	Metrics
American River College	70.8% of Beacon students pass introductory algebra: 42.7% of non-Beacon students pass. 72.5% of Beacon students pass intermediate algebra: 53.5% of non-Beacon students pass.
Chandler-Gilbert Community College	80.6% of MARS students pass introductory algebra: 53.3% of students in non-MARS section pass. 68% of MARS students successfully complete college algebra: 48% of students who enroll in non-MARS introductory algebra successfully pass college algebra
Community College of Denver	62% placed into introductory algebra receive a "C" or better 70% of students in college algebra who were placed into introductory algebra receive a "C" or better 55% placed into intermediate algebra receive a "C" or better
De Anza College	90% of MPS passed introductory algebra compared with 49% of non-MPS students. 89% of MPS students passed intermediate algebra compared with 58% of non-MPS students. 89% of MPS students passed elementary statistics compared with 69% of non-MPS students
Green River Community College	77% in elementary algebra receive 2.5 or higher 85% of students who complete elementary algebra and enroll in intermediate algebra receive a 2.0 or higher 38% of students first enrolled in elementary algebra pass first college-level math course
Miami Dade College	72% pass college preparatory math.

College	Metrics
	24% who begin this course will pass a college-level course within 3 years 78% pass intermediate algebra. 53% who begin this course will pass a college-level course within 3 years
Mt. San Antonio College	49.2% pass elementary algebra 53.7% pass intermediate algebra
Northwest Vista College	64% pass introduction to algebra and geometry with a "C" or better 61% pass elementary algebra with a "C" or better 66% pass intermediate algebra with a "C" or better 73% who placed into introduction to algebra and attempt college algebra receive a "C" or better 21% who placed into introduction to algebra receive a "C" or better in college algebra 37% who placed into elementary algebra receive a "C" or better in college algebra
Onondaga Community College	52% in instructor-led beginning algebra receive a "B" or better 80% in online beginning algebra receive a "B" or better 46.4% in intermediate algebra receive a "B" or better 79.5% of students completing developmental algebra and who enroll in college algebra or comparable course receive a "C" or better, compared to 68.7% of non-developmental math students
Zane State College	77% receive "C" or better in introduction to algebra 70% receive "C" or better in algebra

GLOSSARY

Accelerated Courses	Courses in which material is covered in a shorter period of time and typically at a higher level of intensity.
Active learning	Learning in which the learner directs the learning and the instructor, if present, facilitates the process. Examples of activities include cooperative learning, collaborative learning, real-world problems, and project-based learning.
Collaborative learning	Learning situations in which students work together in small groups towards a common goal. Students are responsible for their own learning as well as that of other members of the group.
Computer Assisted Instruction	A computer-based supplement to traditional instructor-led instruction that commonly includes drill-and-practice, tutorial, or simulation activities.
Cooperative learning	See collaborative learning.
Critical thinking	The process of conceptualizing, analyzing, and evaluating information in order to solve a problem or reach a conclusion.
Intelligence Tutoring Systems	Computer-assisted instructional systems employing the principles of artificial intelligence.
Project-based learning	Learning in which students work in small group to investigate longer-term interdisciplinary projects that incorporate real-world issues.
Randomized controlled trial experiment	Experimental design in which subjects are randomly selected to participate in an intervention, or experimental approach. Those subjects not selected are part of the control group. Outcomes are then compared across the two groups

Real-world problems	Variety of applications intended to illustrate how a particular concept is applied to the natural or physical world, for instance, and can include short word problems and lengthy projects that require students to collect, analyze, and interpret their own data.
Self-selection bias	Bias in research that results when individuals have choice over different approaches. An example in education research is if students have choice of particular pedagogical approaches for the same course.

BIBLIOGRAPHY

ALEKS Web site. http://www.aleks.com (accessed March 15, 2005).

American Council on Education Web site. www.acenet.edu/clll/ged/scoring-TT.cfm (accessed Aug. 4, 2004).

American Diploma Project. 2004. *Ready or not: Creating a high school diploma that counts.* The American Diploma Project. Achieve, Inc.

American Mathematical Association of Two-Year Colleges. 1995. *Crossroads in mathematics: Standards for introductory college mathematics before calculus*. D. Cohen, ed. Memphis, Tenn.: American Mathematical Association of Two-Year Colleges.

———. 2002a. The Crossroads Revisited Project: The American Mathematical Association of Two-Year Colleges executive summary of research on the effect of Crossroads. http://www.amatyc.org/Crossroads/execsummaryARG.html (accessed Nov. 20, 2003).

———. 2002b. *A Vision: Final report from the National Conference on Technical Mathematics for Tomorrow.* http://www.wake.tec.nc.us/~rlkimbal/CRAFTY/webvision.pdf (accessed Feb. 10, 2004).

American Society for Training & Development. 2000. Evaluating the effectiveness and return on investment of e-learning. *What Works Online.* 2nd Quarter.

American Society for Training & Development Web site. http://www.astd.org. (accessed June 15, 2005).

Armed Services Vocational Aptitude Battery Web site. http://www.asvabprogram.com/index.cfm?fuseaction=overview.test (accessed Oct. 22, 2003).

Barr, J. 2005. American River College Beacon program: An environment where students learn how to learn. Summary report for 17 semesters: 1993-2004. American River College.

Barth, P. 2002. Add it up: Mathematics education in the U.S. does not compute. Education Trust. ERIC, ED 470539.

Bilodeau, D. 2003. *Automating Army's Basic Skills program* briefing, July 9, 2003. http://www.ww-003.com/Session%2046/46_bilodeau.pdf (accessed Oct. 23, 2003).

Boylan, H. R., and D. Saxon. 2002. *What works in remediation: Lessons learned from 30 years of research.* Boone, N.C.: Appalachian State University, National Center for Developmental Education.

Brooks/Cole Web site. http://www.brookscole.com. (accessed March 13, 2005).

Bureau of Labor Statistics (BLS). 2001. *News release: Employment and total job openings by education or training category, 2000-2010*. Washington, D.C.: U.S. Department of Labor. http://www.bls.gov/news.release/ecopro.toc .htm (accessed Oct. 31, 2003).

Bureau of Labor Statistics (BLS) Web site. http://www.bls.gov. (accessed April 25, 2005).

California Community College Chancellor's Office Data Mart Web site http://www.cccco.edu/divisions/tris/mis/reports.htm. (accessed July 7, 2004).

College Reading and Learning Association Web site. http://www.crla.net/tutorcert.htm. (accessed May 3, 2005).

Community College Survey of Student Engagement (CCSSE) Web site http://www.ccsse.org. (accessed Dec. 8, 2004).

_____________. 2004. *Highlights*. Vol. 3, Issue 4. http://www.ccsse.org/publications/March2004.pdf. (accessed April 14, 2005).

_____________. 2004(b). *Highlights*. Vol. 3, Issue 5. http://www.ccsse.org/publications/March2004.pdf. (accessed April 14, 2005).

Community College Week Web site http://www.ccweek.com/Top1002004.asp#. (accessed May 9, 2005).

Conley, D., and F. Bodone. 2002. University expectations for student success: Implications for system alignment and state standard and assessment policies. Center for Education Policy Research, University of Oregon. ERIC, ED 464922.

Cutright, M., and R. Swing, "The Community College of Denver: A second family for the first-year student." In *Achieving and sustaining institutional excellence for the first year of college.* Ed. B. Barefoot and J. Gardner (Jossey-Bass. 2005). 35-58.

Defense Technical Information Center Web site. http://www.dtic.mil. (accessed Oct 2003).

ERIC Web site. http://www.eric.ed.gov. (accessed March 14, 2005).

Garcia, Federico. 1998. *Effectiveness of the voluntary education program.* CNA Research Memorandum 98-40.

Golfin, Peggy, et al. 2005. *Strengthening mathematics skills at the postsecondary level: Literature review and analysis.* Washington, D.C., Office of Vocational and Adult Education, U.S. Department of Education.

Grubb, N. W. 1999. Innovative practices: The pedagogical and institutional challenges. In W. N. Grubb (ed.), *Honored but invisible: An inside look at teaching in community colleges* (pp. 245-279). New York: Routledge.

Hoffman, K., C. Llagas, and T. Snyder. 2003. *Status and trends in the education of blacks.* National Center for Education Statistics. NCES document 2003034. http://nces.ed.gov/ pubs2003/2003034.pdf. (accessed April 13, 2005).

Houghton-Mifflin Web site. http://www.hmco.com. (accessed March 14, 2005).

Integrated Postsecondary Education Data System (IPEDS) Web site. http://nces.ed.gov/ipeds/cool/GRS.asp. (accessed April 13, 2005).

Johnson County Community College, Office of Institutional Research. 2004. *National community college benchmark project report of 2004 aggregate data, prepared for San Antonio College.* http://www.accd.edu/sac/instplan/MINUTES/2004NCCBenchmark.pdf. (accessed April 11, 2005).

Juhnke, Ralph. Senior Research Analyst, Office of Institutional Research, Johnson County Community College. In correspondence with Ralph Juhnke of the Johnson County Community College. Nov. 2004.

Kansas Board of Regents. March 2004. Kansas postsecondary core indicators of effectiveness: Kansas community colleges, technical colleges and area

technical schools (preliminary data tables for academic year 2002-2003 collection period). http://www.kansasregents.org/download/commcollege/CoreTables2003.pdf. (accessed Aug. 1, 2004).

KeyTrain Web site. http://www.keytrain.com. (accessed June 1, 2005).

League for Innovation Web site. http://www.league.org/league/projects/lcp/champions.htm. (accessed May 9, 2005).

Lis, James. U.S. Coast Guard Team Lead, Education and Training Programs. In correspondence with James Lis of the U.S. Coast Guard. Dec. 2004.

Lum, G. 2003. *Developmental math report.* Harrisburg Area Community College Office of Institutional Research and Planning.

Maricopa District Web site. http://www.dist.maricopa.edu/m2c/. (accessed May 27, 2005).

McCabe, R. 2000. No one to waste: A report to public decision-makers and community college leaders. Washington, D.C.: Community College Press.

McGraw-Hill Web site. http://catalogs.mhhe.com/mhhe/home.do (accessed March 9, 2005).

Miami Dade College. 2004. Quality enhancement plan: Student success at Miami Dade College: The mathematics connection. Miami Dade College.

Miami Dade College Web site. http://www.mdc.edu/ir/MDCstudents.ppt. (accessed April 13, 2005).

Military.com Web site. http://www.military.com/Resources/ResourcesContent/0,13964,32879,00.html (accessed Nov. 10, 2003).

Minnesota MATYC Web site. http://willmar.ridgewater.mnscu.edu/mnmatyc/Conference2005/technology_demonstrations.htm (accessed July 5, 2005).

National Association for Developmental Education. http://www.hcc-online.org/chris/nade/what_is_nade.asp. (accessed May 2, 2005).

National Association of Manufacturers Center for Work Success. *The skills gap 2001.* http://www.nam.org/docs/centerforworkforcesuccess/23975_namskillsgapforpress.pdf (accessed Nov. 2, 2003).

National Center for Education Statistics (NCES). 2000. *Descriptive summary of 1995-96 beginning postsecondary students: Three years later.* Washington, D.C.: U.S. Department of Education. http://nces.ed.gov/pubs2000/2000154.pdf (accessed March 11, 2005).

______ 2003. *Digest of higher education statistics*. Washington D.C.: U.S. Department of Education. http://nces.ed.gov/programs/digest/d03/list_tables.asp (accessed March 17, 2005).

——— (b). 2003. *Remedial education at degree-granting postsecondary institutions in fall 2000.* Washington, D.C.: U.S. Department of Education. http://nces.ed.gov/pubs2004/2004010.pdf (accessed Dec. 1, 2003).

_____ (c). 2004. *Enrollment in postsecondary institutions, fall 2002 and financial statistics, fiscal year 2002.* Washington, D.C.: U.S. Department of Education. http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2005168. (accessed Jan. 27, 2005).

______ National Postsecondary Student Aid Study Web site. http://nces.ed.gov/surveys/npsas/index.asp. (accessed May 26, 2005).

New Mexico Association of Community Colleges. *Meeting our mission 2003-2004.* http://www.nmacc.org/PDFS/03meetingmissions.pdf. (accessed July 14, 2004).

Noel-Levitz Web site. http://www.noellevitz.com. (accessed April 25, 2005).

Noel-Levitz Web site (b). http://www.noellevitz.com/NR/rdonlyres/341ED4FF-3066-4596-9375-0B3E0567F3B0/0/04ACTdata.pdf. (accessed May 2, 2005).

Northwest Arkansas Community College Web site. http://www.nwacc.edu/stuachieve/develop/php. (accessed July 15, 2004).

Onondaga Community College Web site. http://www.sunyocc.edu/departments/oirp/Fallstatistics.htm#Enrollme

nt. (accessed April 11, 2005).

Pearson Education Web site. http://vig.prenhall.com/catalog/academic/discipline/0,1142,2040,00.html (accessed March 9, 2005).

Pennsylvania Commission for Community Colleges Web site. http://www.pacommunitycolleges.org/database/AT18.pdf. (accessed July 16, 2004).

Piedmont Valley Community College Web site. www.pvcc.edu/ir/carpe%20data/developmental%20math%20cd.pdf. (accessed July 6, 2004).

PLATO Web site. http://(www.plato.com. (accessed Jan. 5, 2005).

Revak, M., S. Frickenstein, and D. Cribb. 1997. *The effects of a practice placement exam on placement exam scores and success in calculus I*. U.S. Air Force Academy publication TR-97-4, Aug. 1997.

Schults, C. 2001. *Remedial education: Practices and policies in community colleges*. American Association of Community Colleges. http://www.aacc.nche.edu/ Content/NavigationMenu/AboutCommunityColleges/Trends_and_Statistics/ EnrollmentInfo/Remedial_Education.htm (accessed Oct. 20, 2003).

Sherry, Heather. Director of Articulation and Student Services, Division of Community Colleges, Florida Department of Education. In correspondence with Heather Sherry of the Florida Department of Education. Oct. 2003.

Shiplet, Tina. Lecturer, Adult Basic Education, UNM-Valencia. In correspondence with Tina Shiplet of the University of New Mexico-Valencia. Aug.2004.

Smarthinking Web site. http://www.smarthinking.com. (accessed March 14, 2005).

Stoskopf, Dian. U.S. Army Chief, Education Division. In correspondence with Dian Stoskopf of the U.S. Army. Dec. 2004.

Sweizer, James. U.S. Air Force Chief, Voluntary Education Program. In correspondence with James Sweizer of the U.S. Army. Dec. 2004.

Taylor, Vernon. U.S., Marine Corps Head, Lifelong Learning. In correspondence with Vernon Taylor of the U.S. Marine Corps. March 2005.

United States Army Fort Hood Web site. http://esd.hood.army/bsep.htm (accessed Nov. 5, 2003).

United States Code, Title 10, Section 520.

United States Department of Defense, Defense Activity for Non-Traditional Education Support (DANTES) Web site. http://www.dantes.doded.mil/dantes_Web/library/docs/voledfacts/fy04.pdf (accessed Jul 1, 2005).

United States Marine Corps MARADMIN no. 057/98. Oct. 5, 1998.

United States Marine Corps Web site. http://www.usmc-mccs.org/perssvc/Life_Learn/prgms_masp.asp (accessed Nov. 6, 2003).

United States Navy College Web site. http://www.navycollege.navy.mil (accessed November 15, 2004).

United States Navy. 2002. COMNAVCRUITCOMINST 1130.8F.

University of Alaska at Fairbanks Web site. http://www.uaf.edu/pair/SP2005_v5.pdf. (accessed July 7, 2004).

Welch, J., and K. DiTomasso. 2004. Youth in ABE. *Focus on Basics, 7(A).* http://gseweb.harvard.edu/~ncsall/fob/2004/welch.html (accessed Dec. 14, 2004).

Winter, Adele. NovaNet Account Executive & Army Consultant (Cadet Command), Pearson Digital Learning. Correspondence with Adele Winter of Pearson Digital Learning. Feb. 2005.